Shikshā in the Physiology

According to the research of Professor Tony Nader, in
Human Physiology: Expression of Veda and the Vedic Literature, 4th Edition,
Maharishi Vedic University, Vlodrop, Holland, 2000,
Shikshā is represented in the physiology by the 36 pairs of autonomic ganglia.

The following excerpts are taken from *Anatomy of the Human Body*, 20th Edition, Henry Gray and Warren Lewis, Lea & Febiger, Philadelphia, 1918, pp. 730-989.

Part I: Description of Nervous System Ganglia

Ganglia are small aggregations of nerve cells. They are found on the posterior roots of the spinal nerves; on the sensory roots of the trigeminal, facial, glossopharyngeal, and vagus nerves, and on the acoustic nerves. They are also found in connection with the sympathetic nerves. On section they are seen to consist of a reddish-gray substance, traversed by numerous white nerve fibers; they vary considerably in form and size; the largest are found in the cavity of the abdomen; the smallest, not visible to the naked eye, exist in considerable numbers upon the nerves distributed to the different viscera. Each ganglion is invested by a smooth

and firm, closely adhering, membranous envelope, consisting of dense areolar tissue; this sheath is continuous with the perineurium of the nerves, and sends numerous processes into the interior to support the bloodvessels supplying the substance of the ganglion.

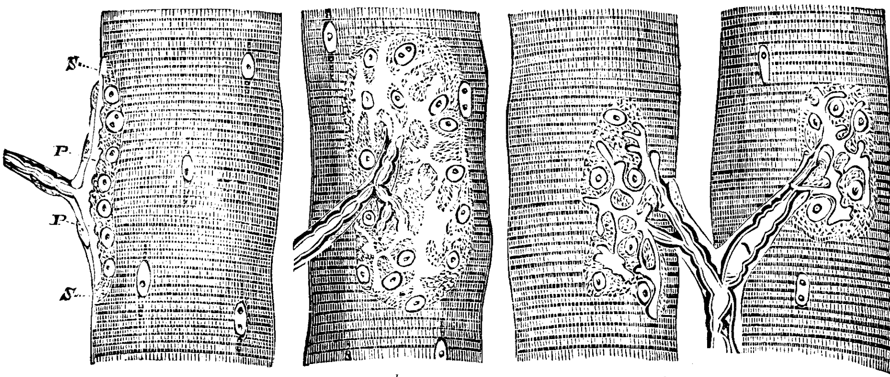


FIG. 637.—Muscular fibers of *Lacerta viridis* with the terminations of nerves. *a*. Seen in profile. *P, P*. The nerve end-plates. *S, S*. The base of the plate, consisting of a granular mass with nuclei. *b*. The same as seen in looking at a perfectly fresh fiber, the nervous ends being probably still excitable. (The forms of the variously divided plate can hardly be represented in a woodcut by sufficiently delicate and pale contours to reproduce correctly what is seen in nature.) *c*. The same as seen two hours after death from poisoning by curare.

In structure all ganglia are essentially similar, consisting of the same structural elements—viz., nerve cells and nerve fibers. Each nerve cell has a nucleated sheath which is continuous with the neurolemma of the nerve fiber with which the cell is connected. The nerve cells in the ganglia of the spinal nerves (Fig. 638) are pyriform in shape, and have each a single process. A short distance from the cell and while still within the ganglion this process divides in a T-shaped manner, one limb of the cross-bar turning into the medulla spinalis, the other limb passing outward to the periphery. In the sympathetic ganglia (Fig. 639) the nerve cells are multipolar and each has one axis-cylinder process and several dendrons; the axon emerges from the ganglion as a non-medullated nerve fiber. Similar cells are found in the ganglia connected with the trigeminal nerve, and these ganglia are therefore

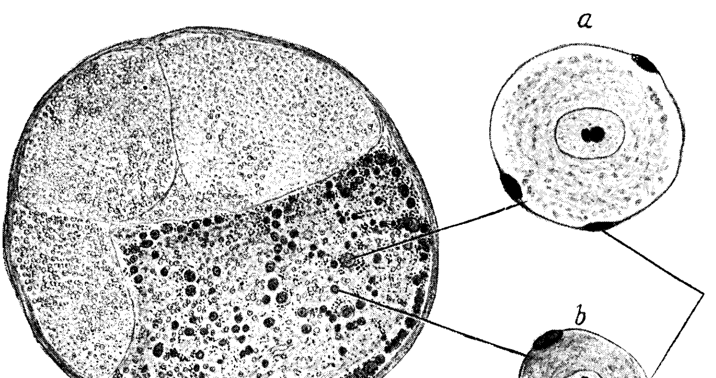


FIG. 638.—Transverse section of spinal ganglion of rabbit. *A*. Ganglion. × 30. *a*. Large clear nerve cell. *b*. Small deeply staining nerve cell. *c*. Nuclei of capsule. × 250. The lines in the center point to the corresponding cells in the ganglion.

regarded as the cranial portions of the sympathetic system. The sympathetic nervous system includes those portions of the nervous mechanism in which a medullated nerve fiber from the central system passes to a ganglion, sympathetic or peripheral, from which fibers, usually non-medullated, are distributed to such structures, *e. g.*, bloodvessels, as are not under voluntary control. The spinal and sympathetic ganglia differ somewhat in the size and disposition of the cells and in the number of nerve fibers entering and leaving them. In the spinal ganglia (Fig. 638) the nerve cells are much larger and for the most part collected in groups near the periphery, while the fibers, which are mostly medullated, traverse the central portion of the ganglion; whereas in the sympathetic ganglia (Fig. 639) the cells are smaller and distributed in irregular groups throughout the whole ganglion; the fibers also are irregularly scattered; some of the entering ones are medullated, while many of those leaving the ganglion are non-medullated.

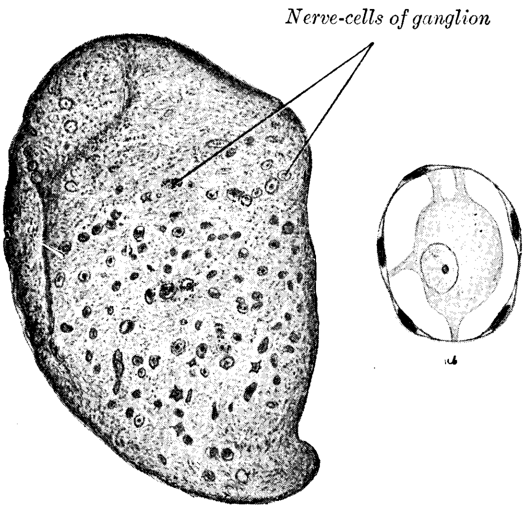


FIG. 639.—Transverse section of sympathetic ganglion of cat. *A*. Ganglion. × 50. *a*. A nerve cell. × 250.

Neuron Theory.—The nerve cell and its processes collectively constitute what is termed a **neuron**, and Waldeyer formulated the theory that the nervous system is built up of numerous neurons, "anatomically and genetically independent of one another." According to this theory (*neuron theory*) the processes of one neuron only come into contact, and are never in direct continuity, with those of other neurons; while impulses are transmitted from one nerve cell to another through these points of contact, the synapses. The **synapse** or **synaptic membrane** seems to allow nervous impulses to pass in one direction only, namely, from the terminals of the axis-cylinder to the dendrons. This theory is based on the following facts, viz.: (1) embryonic nerve cells or neuroblasts are entirely distinct from one another; (2) when nervous tissues are stained by the Golgi method no continuity is seen even between neighboring neurons; and (3) when degenerative changes occur in nervous tissue, either as the result of disease or experiment, they never spread from one neuron to another, but are limited to the individual neurons, or groups of neurons, primarily affected.

For the present we may look upon the neurons as the units or structural elements of the nervous system. All the neurons are present at birth which are present in the adult, their division ceases before birth; they are not all functionally active at birth, but gradually assume functional activity. There is no indication of any regeneration after the destruction of the cell-body of any individual neuron.

Part II: Incoming (afferent) and Outgoing (efferent) fibres of the autonomic Ganglia

Sympathetic afferent fibers (*visceral afferent; viscero-sensory; splanchnic afferent*) enter the spinal cord by the posterior roots of the thoracic and first two or three lumbar nerves and the second to the fourth sacral nerves. The fibers pass to these nerves from the peripheral sympathetic system through the white rami communicantes. Some of the cell bodies of these afferent fibers are located in the spinal ganglia and others are in the sympathetic ganglia. Some of the afferent sympathetic fibers end about the cell bodies of somatic sensory neurons and visceral impulses are thus transmitted to these neurons which conduct them as well as their own special impulses to the spinal cord. Other sympathetic afferent neurons whose cell bodies are located in the spinal ganglia send collaterals to neighboring cells of somatic sensory neurons and thus have a double path of transmission to the spinal cord. Such an arrangement provides a mechanism for some of the referred pains.

These sympathetic afferent fibers presumably divide on entering the spinal cord into ascending and descending branches. Their distribution and termination within the spinal cord are unknown. Some of them probably eventually come into relation with the sympathetic efferent fibers whose cell bodies are located in the lateral column. Our knowledge concerning both the termination and origin of these fibers is very unsatisfactory.

The **sympathetic efferent fibers** (*splanchnic motor; viscero-motor; preganglionic fibers*) are supposed to arise from cells in the intermediate zone between the dorsal and ventral gray columns and in the intermedio-lateral column at the margin of the lateral column. These preganglionic sympathetic fibers are not distributed throughout the entire series of spinal nerves but are confined to two groups, the thoraco-lumbar from the first thoracic to the second or third lumbar nerves and the sacral group from the second to the fourth sacral nerves. They pass out with the anterior root fibers and through the rami communicantes to end in sympathetic ganglia. The impulses are distributed from cells in these ganglia through post-ganglionic fibers to the smooth muscles and glands. The thoraco-lumbar outflow and the sacral outflow form two distinct functional groups which are considered more fully under the sympathetic system.

Part III: Connections between the spinal nerves, the spinal ganglia, and the autonomic ganglia

Connections with Sympathetic.—Immediately beyond the spinal ganglion, the anterior and posterior nerve roots unite to form the **spinal nerve** which emerges through the intervertebral foramen. Each spinal nerve receives a branch (**gray ramus communicans**) from the adjacent ganglion of the sympathetic trunk, while the thoracic, and the first and second lumbar nerves each contribute a branch (**white ramus communicans**) to the adjoining sympathetic ganglion. The second, third, and fourth sacral nerves also supply white rami; these, however, are not connected with the ganglia of the sympathetic trunk, but run directly into the pelvic plexuses of the sympathetic.

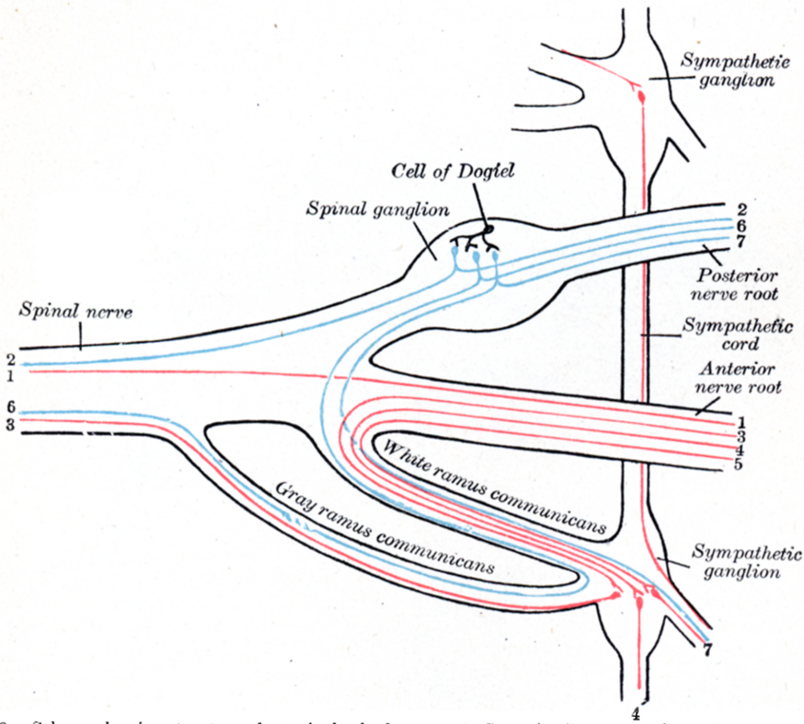


Fig. 799.—Scheme showing structure of a typical spinal nerve. 1. Somatic efferent. 2. Somatic afferent. 3, 4, 5. Sympathetic efferent. 6, 7. Sympathetic afferent.

Structure.—Each typical spinal nerve contains fibers belonging to two systems, viz., the **somatic,** and the **sympathetic** or **splanchnic,** as well as fibers connecting these systems with each other (Fig. 799).

1. The **somatic fibers** are efferent and afferent. The *efferent fibers* originate in the cells of the anterior column of the medulla spinalis, and run outward through the anterior nerve roots to the spinal nerve. They convey impulses to the voluntary muscles, and are continuous from their origin to their peripheral distribution. The *afferent fibers* convey impressions inward from the skin, etc., and originate in the unipolar nerve cells of the spinal ganglia. The single processes of these cells divide into peripheral and central fibers, and the latter enter the medulla spinalis through the posterior nerve roots.

2. The **sympathetic fibers** are also efferent and afferent. The *efferent* fibers, preganglionic fibers, originate in the lateral column of the medulla spinalis, and are conveyed through the anterior nerve root and the white ramus communicans to the corresponding ganglion of the sympathetic trunk; here they may end by forming synapses around its cells, or may run through the ganglion to end in another of the ganglia of the sympathetic trunk, or in a more distally placed ganglion

in one of the sympathetic plexuses. In all cases they end by forming synapses around other nerve cells. From the cells of the ganglia of the sympathetic trunk other fibers, postganglionic fibers, take origin; some of these run through the gray rami communicantes to join the spinal nerves, along which they are carried to the bloodvessels of the trunk and limbs, while others pass to the viscera, either directly or after interruption in one of the distal ganglia. The *afferent* fibers are derived partly from the unipolar cells and partly from the multipolar cells of the spinal ganglia. Their peripheral processes are carred through the white rami communicantes, and after passing through one or more sympathetic ganglia (but always without interruption in them) finally end in the tissues of the viscera. The central processes of the unipolar cells enter the medulla spinalis through the posterior nerve root and form synapses around either somatic or sympathetic efferent neurons, thus completing reflex arcs. The dendrites of the multipolar nerve cells form synapses around the cells of type II (cells of Dogiel) in the spinal ganglia, and by this path the original impulse is transferred from the sympathetic to the somatic system, through which it is conveyed to the sensorium.

Divisions.—After emerging from the intervertebral foramen, each spinal nerve gives off a small **meningeal branch** which reënters the vertebral canal through the intervertebral foramen and supplies the vertebræ and their ligaments, and the bloodvessels of the medulla spinalis and its membranes. The spinal nerve then splits into a **posterior or dorsal**, and an **anterior or ventral division**, each receiving fibres from both nerve roots.

Part IV: Shamāna Shikshā correlated with the Ciliary ganglion

The Ciliary Ganglion (*ophthalmic or lenticular ganglion*) (Figs. 775, 777).—The ciliary ganglion is a small, sympathetic ganglion, of a reddish-gray color, and about the size of a pin's head; it is situated at the back part of the orbit, in some loose fat between the optic nerve and the Rectus lateralis muscle, lying generally on the lateral side of the ophthalmic artery.

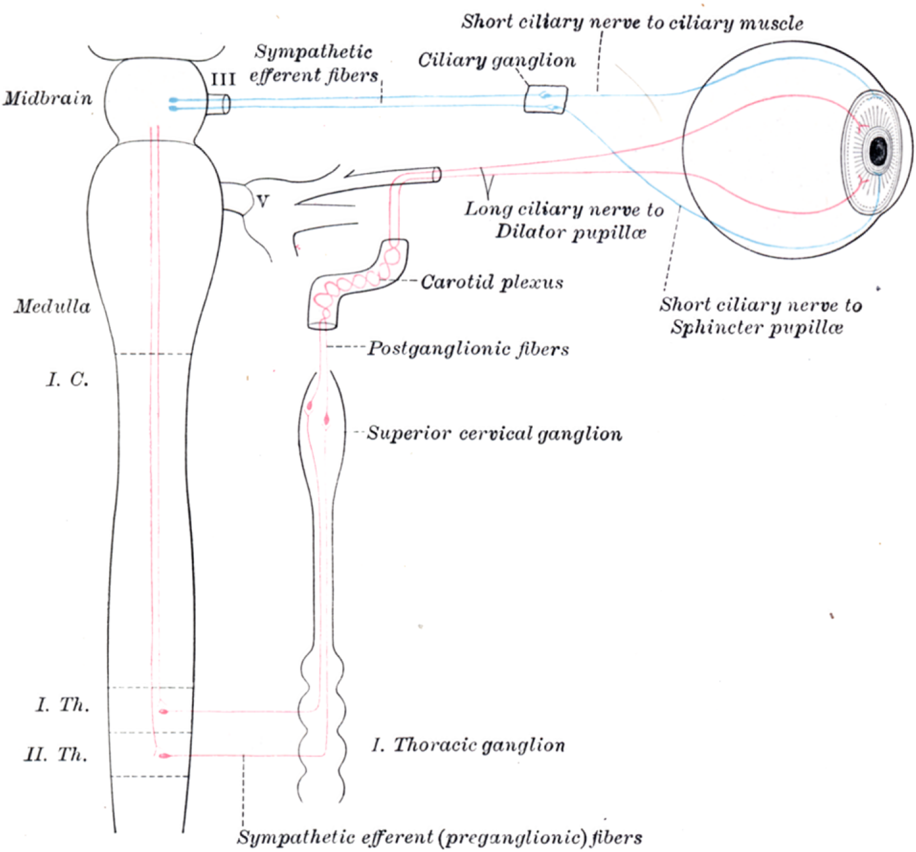


FIG. 840.—Sympathetic connections of the ciliary and superior cervical ganglia.

Its **roots** are three in number, and enter its posterior border. One, the long or sensory root, is derived from the nasociliary nerve, and joins its postero-superior angle. The second, the short or motor root, is a thick nerve (occasionally divided into two parts) derived from the branch of the oculomotor nerve to the Obliquus inferior, and connected with the postero-inferior angle of the ganglion. The motor root is supposed to contain sympathetic efferent fibers (preganglionic fibers) from the nucleus of the third nerve in the mid-brain to the ciliary ganglion where they form synapses with neurons whose fibers (postganglionic) pass to the Ciliary muscle and to Sphincter muscle of the pupil. The third, the sympathetic root, is a slender filament from the cavernous plexus of the sympathetic; it is frequently blended with the long root. According to Tiedemann, the ciliary ganglion receives a twig of communication from the sphenopalatine ganglion.

Its **branches** are the **short ciliary nerves.** These are delicate filaments, from six to ten in number, which *arise* from the forepart of the ganglion in two bundles connected with its superior and inferior angles; the lower bundle is the larger. They run forward with the ciliary arteries in a wavy course, one set above and the other below the optic nerve, and are accompanied by the long ciliary nerves from the nasociliary. They pierce the sclera at the back part of the bulb of the eye, pass forward in delicate grooves on the inner surface of the sclera, and are distributed to the Ciliaris muscle, iris, and cornea. Tiedemann has described a small branch as penetrating the optic nerve with the arteria centralis retinæ.

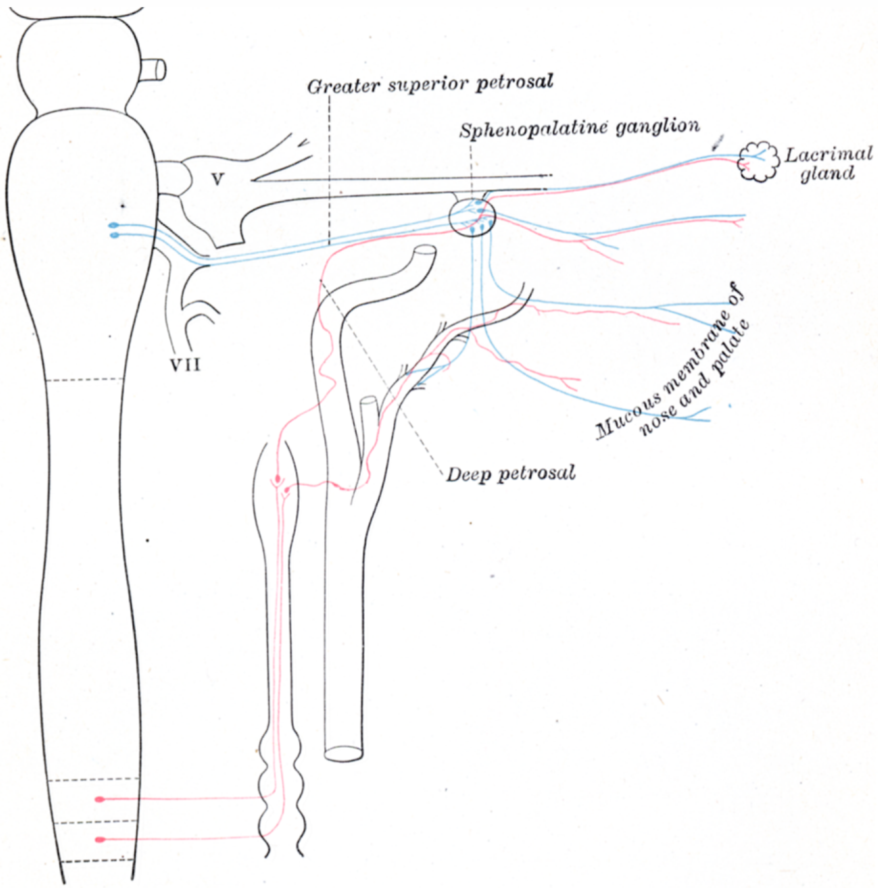


FIG. 841.—Sympathetic connections of the sphenopalatine and superior cervical ganglia.

The **nerve of the pterygoid canal** (*n. canalis pterygoidei* [*Vidii*]; *Vidian nerve*), formed by the junction of the two preceding nerves in the cartilaginous substance which fills the foramen lacerum, passes forward, through the pterygoid canal, with the corresponding artery, and is joined by a small ascending **sphenoidal branch** from the otic ganglion. Finally, it enters the pterygopalatine fossa, and joins the posterior angle of the sphenopalatine ganglion.

Branches of Distribution.—These are divisible into four groups, viz., **orbital, palatine, posterior superior nasal,** and **pharyngeal.**

The **orbital branches** (*rami orbitales; ascending branches*) are two or three delicate filaments, which enter the orbit by the inferior orbital fissure, and supply the periosteum. According to Luschka, some filaments pass through foramina in the frontoethmoidal suture to supply the mucous membrane of the posterior ethmoidal and sphenoidal sinuses.

The **palatine nerves** (*nn. palatini; descending branches*) are distributed to the roof of the mouth, soft palate, tonsil, and lining membrane of the nasal cavity. Most of their fibers are derived from the sphenopalatine branches of the maxillary nerve. They are three in number: **anterior, middle,** and **posterior.**

The **anterior palatine nerve** (*n. palatinus anterior*) descends through the pterygopalatine canal, emerges upon the hard palate through the greater palatine foramen, and passes forward in a groove in the hard palate, nearly as far as the incisor teeth. It supplies the gums, the mucous membrane and glands of the hard palate, and communicates in front with the terminal filaments of the nasopalatine nerve. While in the pterygopalatine canal, it gives off **posterior inferior nasal branches,** which enter the nasal cavity through openings in the palatine bone, and ramify over the inferior nasal concha and middle and inferior meatuses; at its exit from the canal, a palatine branch is distributed to both surfaces of the soft palate.

The **middle palatine nerve** (*n. palatinus medius*) emerges through one of the minor palatine canals and distributes branches to the uvula, tonsil, and soft palate. It is occasionally wanting.

The **posterior palatine nerve** (*n. palatinus posterior*) descends through the pterygopalatine canal, and emerges by a separate opening behind the greater palatine foramen; it supplies the soft palate, tonsil, and uvula. The middle and posterior palatine join with the tonsillar branches of the glossopharyngeal to form a plexus (**circulus tonsillaris**) around the tonsil.

The **posterior superior nasal branches** (*rami nasales posteriores superiores*) are distributed to the septum and lateral wall of the nasal fossa. They enter the posterior part of the nasal cavity by the sphenopalatine foramen and supply the mucous membrane covering the superior and middle nasal conchæ, the lining of the posterior ethmoidal cells, and the posterior part of the septum. One branch, longer and larger than the others, is named the **nasopalatine nerve.** It enters the nasal cavity through the sphenopalatine foramen, passes across the roof of the nasal cavity below the orifice of the sphenoidal sinus to reach the septum, and then runs obliquely downward and forward between the periosteum and mucous membrane of the lower part of the septum. It descends to the roof of the mouth through the incisive canal and communicates with the corresponding nerve of the opposite side and with the anterior palatine nerve. It furnishes a few filaments to the mucous membrane of the nasal septum.

The **pharyngeal nerve** (*pterygopalatine nerve*) is a small branch *arising* from the posterior part of the ganglion. It passes through the pharyngeal canal with the pharyngeal branch of the internal maxillary artery, and is distributed to the mucous membrane of the nasal part of the pharynx, behind the auditory tube.

Part VI: Svaravyanjana Shikshā correlated with the Oticum ganglion (Otic ganglion in the text)

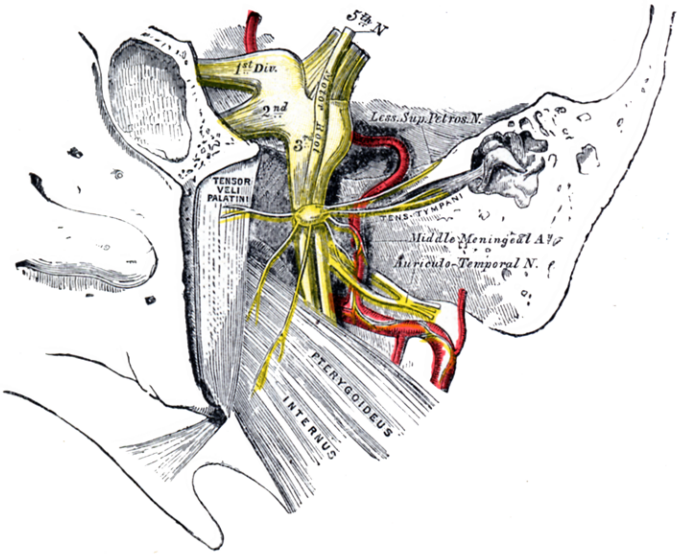


FIG. 783.—The otic ganglion and its branches.

Otic Ganglion (*ganglion oticum*) (Fig. 783).—The otic ganglion is a small, oval-shaped, flattened ganglion of a reddish-gray color, situated immediately below the foramen ovale; it lies on the medial surface of the mandibular nerve, and surrounds the origin of the nerve to the Pterygoideus internus. It is in relation, *laterally*, with the trunk of the mandibular nerve at the point where the motor and sensory roots join; *medially*, with the cartilaginous part of the auditory tube, and the origin of the Tensor veli palatini; *posteriorly*, with the middle meningeal artery.

Branches of Communication.—It is connected by two or three short filaments with the nerve to the Pterygoideus internus, from which it may obtain a motor, and possibly a sensory root. It communicates with the glossopharyngeal and facial nerves, through the lesser superficial petrosal nerve continued from the tympanic plexus, and through this nerve it probably receives a root from the glosso-pharyngeal and a motor root from the facial; its sympathetic root consists of a filament from the plexus surrounding the middle meningeal artery. The fibers from the glossopharyngeal which pass to the otic ganglion in the small superficial petrosal are supposed to be sympathetic efferent (preganglionic) fibers from the

dorsal nucleus or inferior salivatory nucleus of the medulla. Fibers (postganglionic) from the otic ganglion with which these form synapses are supposed to pass with the auriculotemporal nerve to the parotid gland. A slender filament (sphenoidal) ascends from it to the nerve of the Pterygoid canal, and a small branch connects it with the chorda tympani.

Its **branches of distribution** are: a filament to the Tensor tympani, and one to the Tensor veli palatini. The former passes backward, lateral to the auditory tube; the latter arises from the ganglion, near the origin of the nerve to the Pterygoideus internus, and is directed forward. The fibers of these nerves are, however, mainly derived from the nerve to the Pterygoideus internus.

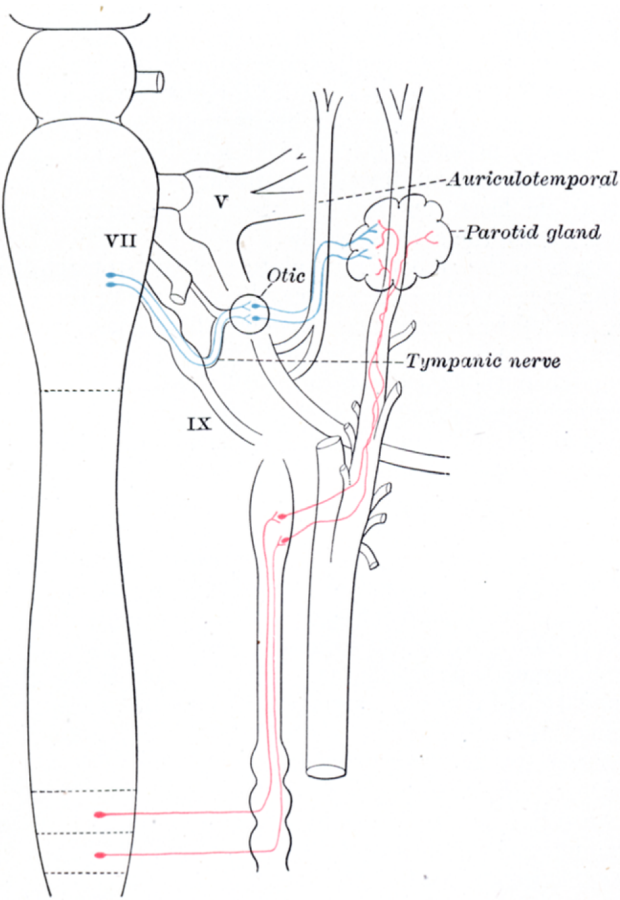


FIG. 843.—Sympathetic connections of the otic and superior cervical ganglia.

Part VII: Shaishirīya Shikshā correlated with the Submandibulare ganglion (Submaxillary in the text)

Submaxillary Ganglion (*ganglion submaxillare*) (Fig. 778).—The submaxillary ganglion is of small size and is fusiform in shape. It is situated above the deep portion of the submaxillary gland, on the hyoglossus, near the posterior border of the Mylohyoideus, and is connected by filaments with the lower border of the lingual nerve. It is suspended from the lingual nerve by two filaments which join the anterior and posterior parts of the ganglion. Through the posterior of these it receives a branch from the chorda tympani nerve which runs in the sheath of the lingual; these are sympathetic efferent (preganglionic) fibers from the facial nucleus or the superior salivatory nucleus of the medulla oblongata that terminate in the submaxillary ganglion. The postganglionic fibers pass to the submaxillary gland, it communicates with the sympathetic by filaments from the sympathetic plexus around the external maxillary artery.

Its **branches of distribution** are five or six in number; they *arise* from the lower part of the ganglion, and supply the mucous membrane of the mouth and the duct of the submaxillary gland, some being lost in the submaxillary gland. The branch of communication from the lingual to the forepart of the ganglion is by some regarded as a branch of distribution, through which filaments pass from the ganglion to the lingual nerve, and by it are conveyed to the sublingual gland and the tongue.

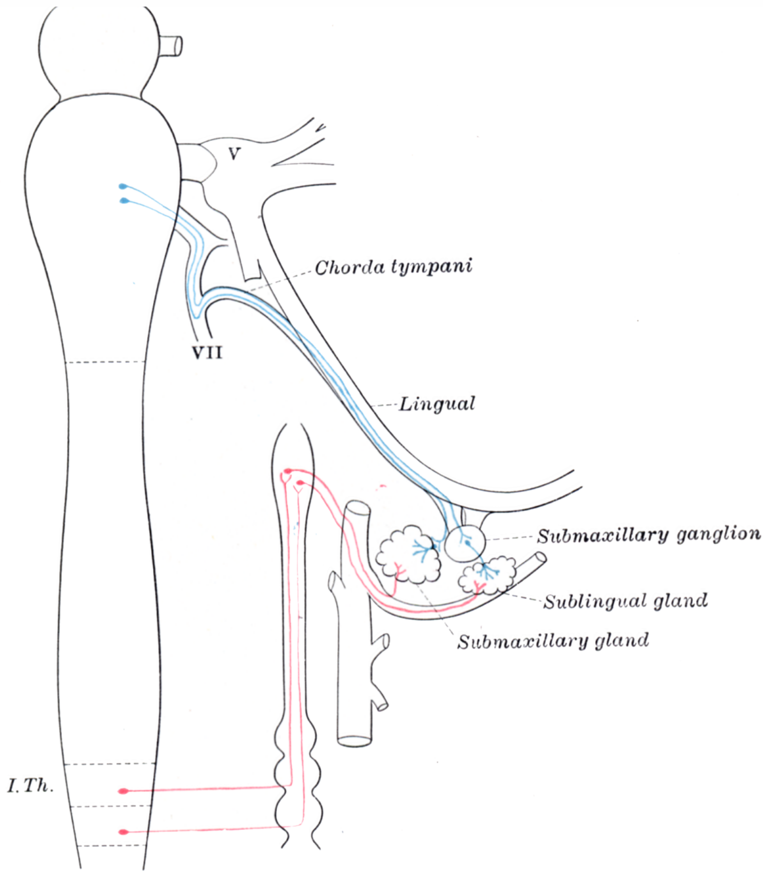


Fig. 842.—Sympathetic connections of the submaxillary and superior cervical ganglia.

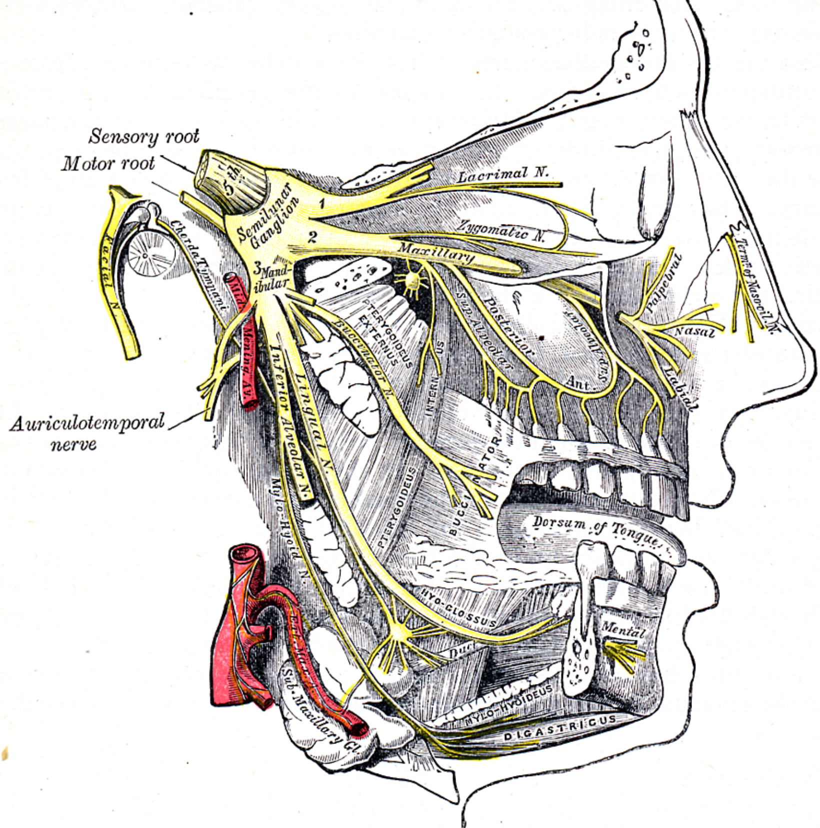


FIG. 778.—Distribution of the maxillary and mandibular nerves, and the submaxillary ganglion.

Part VIII: Vyāsa Shikshā correlated with the two celiac ganglia belonging to the solar plexus

The Celiac Plexus (**Plexus Cœliacus; Solar Plexus**) (Figs. 838, 848).

The **celiac plexus**, the largest of the three sympathetic plexuses, is situated at the level of the upper part of the first lumbar vertebra and is composed of two large ganglia, the **celiac ganglia**, and a dense net-work of nerve fibers uniting them together. It surrounds the celiac artery and the root of the superior mesenteric artery. It lies behind the stomach and the omental bursa, in front of the crura of the diaphragm and the commencement of the abdominal aorta, and between the suprarenal glands. The plexus and the ganglia receive the greater and lesser splanchnic nerves of both sides and some filaments from the right vagus, and give off numerous secondary plexuses along the neighboring arteries.

The **Celiac Ganglia** (*ganglia cœliaca; semilunar ganglia*) are two large irregularly-shaped masses having the appearance of lymph glands and placed one on either side of the middle line in front of the crura of the diaphragm close to the suprarenal glands, that on the right side being placed behind the inferior vena cava. The upper part of each ganglion is joined by the greater splanchnic nerve, while the lower part, which is segmented off and named the **aorticorenal ganglion**, receives the lesser splanchnic nerve and gives off the greater part of the renal plexus.

The secondary plexuses springing from or connected with the celiac plexus are the

Phrenic.	Renal.
Hepatic.	Spermatic.
Lienal.	Superior mesenteric.
Superior gastric.	Abdominal aortic.
Suprarenal.	Inferior mesenteric.

The **phrenic plexus** (*plexus phrenicus*) accompanies the inferior phrenic artery to the diaphragm, some filaments passing to the suprarenal gland. It *arises* from the upper part of the celiac ganglion, and is larger on the right than on the left side. It receives one or two branches from the phrenic nerve. At the point of junction of the right phrenic plexus with the phrenic nerve is a small ganglion

(**ganglion phrenicum**). This plexus distributes branches to the inferior vena cava, and to the suprarenal and hepatic plexuses.

The **hepatic plexus** (*plexus hepaticus*), the largest offset from the celiac plexus, receives filaments from the left vagus and right phrenic nerves. It accompanies the hepatic artery, ramifying upon its branches, and upon those of the portal vein in the substance of the liver. Branches from this plexus accompany all the divisions of the hepatic artery. A considerable plexus accompanies the gastroduodenal artery and is continued as the **inferior gastric plexus** on the right gastroepiploic artery along the greater curvature of the stomach, where it unites with offshoots from the lienal plexus.

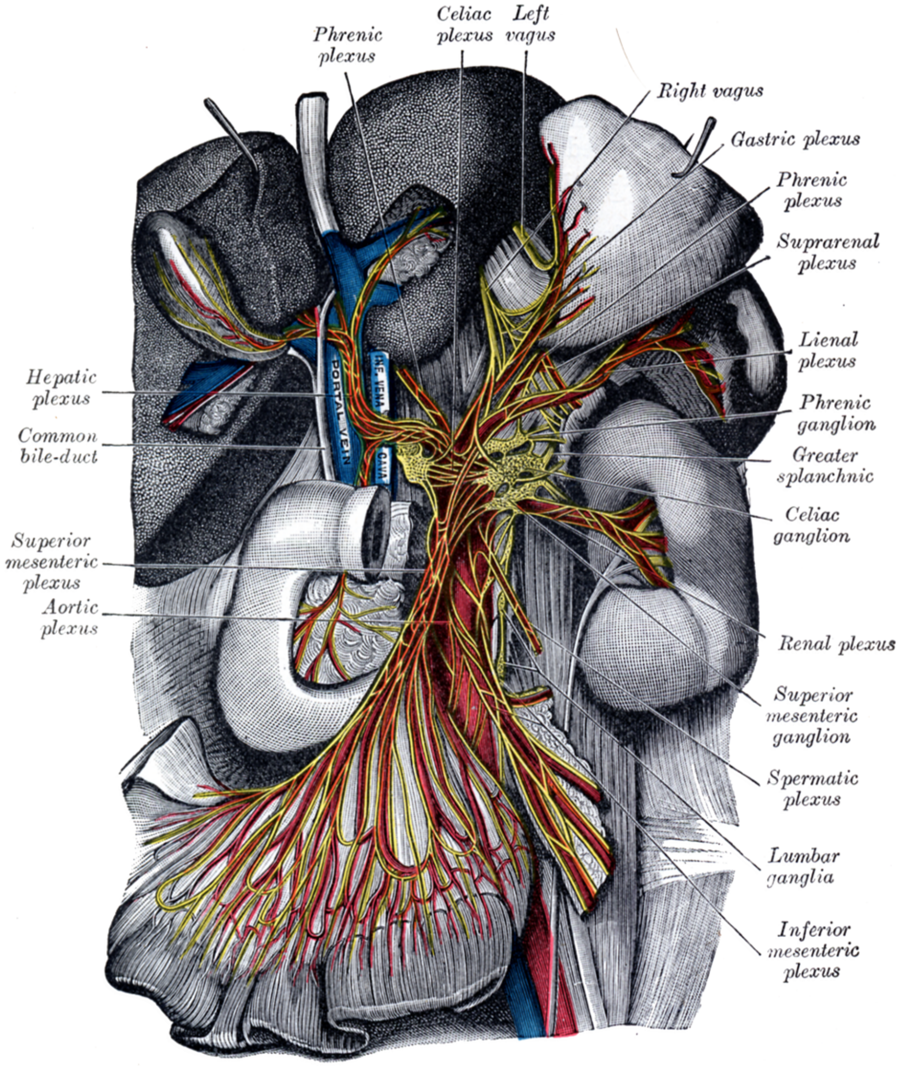


FIG. 848.—The celiac ganglia with the sympathetic plexuses of the abdominal viscera radiating from the ganglia. (Toldt.)

The **lienal plexus** (*plexus lienalis; splenic plexus*) is formed by branches from the celiac plexus, the left celiac ganglion, and from the right vagus nerve. It accompanies the lienal artery to the spleen, giving off, in its course, subsidiary plexuses along the various branches of the artery.

The **superior gastric plexus** (*plexus gastricus superior; gastric or coronary plexus*) accompanies the left gastric artery along the lesser curvature of the stomach, and joins with branches from the left vagus.

The **suprarenal plexus** (*plexus suprarenalis*) is formed by branches from the celiac plexus, from the celiac ganglion, and from the phrenic and greater splanchnic nerves, a ganglion being formed at the point of junction with the latter nerve. The plexus supplies the suprarenal gland, being distributed chiefly to its medullary portion; its branches are remarkable for their large size in comparison with that of the organ they supply.

The **renal plexus** (*plexus renalis*) is formed by filaments from the celiac plexus, the aorticorenal ganglion, and the aortic plexus. It is joined also by the smallest splanchnic nerve. The nerves from these sources, fifteen or twenty in number, have a few ganglia developed upon them. They accompany the branches of the renal artery into the kidney; some filaments are distributed to the spermatic plexus and, on the right side, to the inferior vena cava.

The **spermatic plexus** (*plexus spermaticus*) is derived from the renal plexus, receiving branches from the aortic plexus. It accompanies the internal spermatic artery to the testis. In the female, the **ovarian plexus** (*plexus arteriæ ovaricæ*) *arises* from the renal plexus, and is distributed to the ovary, and fundus of the uterus.

The **superior mesenteric plexus** (*plexus mesentericus superior*) is a continuation of the lower part of the celiac plexus, receiving a branch from the junction of the right vagus nerve with the plexus. It surrounds the superior mesenteric artery, accompanies it into the mesentery, and divides into a number of secondary plexuses, which are distributed to all the parts supplied by the artery, viz., pancreatic branches to the pancreas; intestinal branches to the small intestine; and ileocolic, right colic, and middle colic branches, which supply the corresponding parts of the great intestine. The nerves composing this plexus are white in color and firm in texture; in the upper part of the plexus close to the origin of the superior mesenteric artery is a ganglion (**ganglion mesentericum superius**).

The **abdominal aortic plexus** (*plexus aorticus abdominalis; aortic plexus*) is formed by branches derived, on either side, from the celiac plexus and ganglia, and receives filaments from some of the lumbar ganglia. It is situated upon the sides and front of the aorta, between the origins of the superior and inferior mesenteric arteries. From this plexus arise part of the spermatic, the inferior mesenteric, and the hypogastric plexuses; it also distributes filaments to the inferior vena cava.

The **inferior mesenteric plexus** (*plexus mesentericus inferior*) is derived chiefly from the aortic plexus. It surrounds the inferior mesenteric artery, and divides into a number of secondary plexuses, which are distributed to all the parts supplied by the artery, viz., the **left colic** and **sigmoid plexuses**, which supply the descending and sigmoid parts of the colon; and the **superior hemorrhoidal plexus**, which supplies the rectum and joins in the pelvis with branches from the pelvic plexuses.

Part IX: Chārāyanīya Shikshā correlated with the Mesentericum Superius (superior mesenteric plexus in the book)

The **superior mesenteric plexus** (*plexus mesentericus superior*) is a continuation of the lower part of the celiac plexus, receiving a branch from the junction of the right vagus nerve with the plexus. It surrounds the superior mesenteric artery, accompanies it into the mesentery, and divides into a number of secondary plexuses, which are distributed to all the parts supplied by the artery, viz., pancreatic branches to the pancreas; intestinal branches to the small intestine; and ileocolic, right colic, and middle colic branches, which supply the corresponding parts of the great intestine. The nerves composing this plexus are white in color and firm in texture; in the upper part of the plexus close to the origin of the superior mesenteric artery is a ganglion (**ganglion mesentericum superius**).

Part X: Ātreya Shikshā correlated with the Mesentericum inferius (inferior mesenteric plexus in the book)

The **inferior mesenteric plexus** (*plexus mesentericus inferior*) is derived chiefly from the aortic plexus. It surrounds the inferior mesenteric artery, and divides into a number of secondary plexuses, which are distributed to all the parts supplied by the artery, viz., the **left colic** and **sigmoid plexuses,** which supply the descending and sigmoid parts of the colon; and the **superior hemorrhoidal plexus,** which supplies the rectum and joins in the pelvis with branches from the pelvic plexuses.

Part XI: The Vāsishtha Shikshā correlated with the Cervicale superius ganglion (superior cervical ganglion in the book)

THE CERVICAL PORTION OF THE SYMPATHETIC SYSTEM (PARS CERVICALIS S. SYMPATHICI).

The **cervical portion** of the sympathetic trunk consists of three ganglia, distinguished, according to their positions, as the **superior, middle,** and **inferior ganglia,** connected by intervening cords. This portion receives no white rami communicantes from the cervical spinal nerves; its spinal fibers are derived from the white rami of the upper thoracic nerves, and enter the corresponding thoracic ganglia of the sympathetic trunk, through which they ascend into the neck.

The **superior cervical ganglion** (*ganglion cervicale superius*), the largest of the three, is placed opposite the second and third cervical vertebræ. It is of a reddish-gray color, and usually fusiform in shape; sometimes broad and flattened, and occasionally constricted at intervals; it is believed to be formed by the coalescence of four ganglia, corresponding to the upper four cervical nerves. It is in relation, in *front,* with the sheath of the internal carotid artery and internal jugular vein; *behind,* with the Longus capitis muscle.

Its **branches** may be divided into **inferior, lateral, medial,** and **anterior.**

The **Inferior Branch** communicates with the middle cervical ganglion.

The **Lateral Branches** (*external branches*) consist of gray rami communicantes to the upper four cervical nerves and to certain of the cranial nerves. Sometimes the branch to the fourth cervical nerve may come from the trunk connecting the upper and middle cervical ganglia. The branches to the cranial nerves consist of delicate filaments, which run to the ganglion nodosum of the vagus, and to the hypoglossal nerve. A filament, the **jugular nerve,** passes upward to the base of the skull, and divides to join the petrous ganglion of the glossopharyngeal, and the jugular ganglion of the vagus.

The **Medial Branches** (*internal branches*) are peripheral, and are the **larnygopharyngeal branches** and the **superior cardiac nerve.**

The **laryngopharyngeal branches** (*rami laryngopharyngei*) pass to the side of the

pharynx, where they join with branches from the glossopharyngeal, vagus, and external laryngeal nerves to form the **pharyngeal plexus.**

The **superior cardiac nerve** (*n. cardiacus superior*) *arises* by two or more branches from the superior cervical ganglion, and occasionally receives a filament from the trunk between the first and second cervical ganglia. It runs down the neck behind the common carotid artery, and in front of the Longus colli muscle; and crosses in front of the inferior thyroid artery, and recurrent nerve. The course of the nerves on the two sides then differ. The **right nerve,** at the root of the neck, passes either in front of or behind the subclavian artery, and along the innominate artery to the back of the arch of the aorta, where it joins the deep part of the cardiac plexus. It is connected with other branches of the sympathetic; about the middle of the neck it receives filaments from the external laryngeal nerve; lower down, one or two twigs from the vagus; and as it enters the thorax it is joined by a filament from the recurrent nerve. Filaments from the nerve communicate with the thyroid branches from the middle cervical ganglion. The **left nerve,** in the thorax, runs in front of the left common carotid artery and across the left side of the arch of the aorta, to the superficial part of the cardiac plexus.

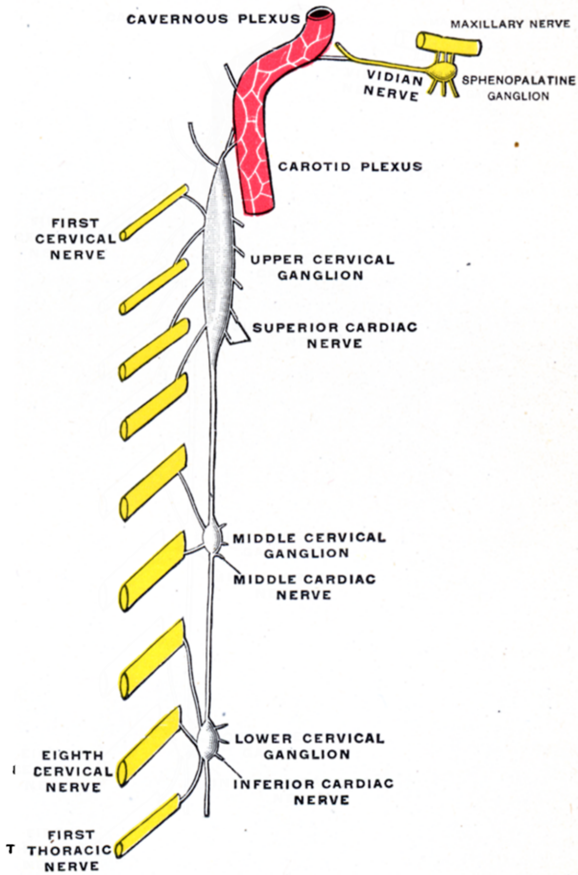


FIG. 844.—Diagram of the cervical sympathetic. (Testut.)

The **Anterior Branches** (*nn. carotici externi*) ramify upon the common carotid artery and upon the external carotid artery and its branches, forming around each a delicate plexus, on the nerves composing which small ganglia are occasionally found. The plexuses accompanying some of these arteries have important communications with other nerves. That surrounding the external maxillary artery communicates with the submaxillary ganglion by a filament; and that accompanying the middle meningeal artery sends an offset to the otic ganglion, and a second, the **external petrosal nerve,** to the genicular ganglion of the facial nerve.

Part XII: The Pāniniya Shikshā correlated with the Cervical medium (called middle cervical ganglion in the book)

The **middle cervical ganglion** (*ganglion cervicale medium*) is the smallest of the three cervical ganglia, and is occasionally wanting. It is placed opposite the sixth cervical vertebra, usually in front of, or close to, the inferior thyroid artery. It is probably formed by the coalescence of two ganglia corresponding to the fifth and sixth cervical nerves.

It sends gray rami communicantes to the fifth and sixth cervical nerves, and gives off the middle cardiac nerve.

The **Middle Cardiac Nerve** (*n. cardiacus medius; great cardiac nerve*), the largest

of the three cardiac nerves, *arises* from the middle cervical ganglion, or from the trunk between the middle and inferior ganglia. On the right side it descends behind the common carotid artery, and at the root of the neck runs either in front of or behind the subclavian artery; it then descends on the trachea, receives a few filaments from the recurrent nerve, and joins the right half of the deep part of the cardiac plexus. In the neck, it communicates with the superior cardiac and recurrent nerves. On the left side, the middle cardiac nerve enters the chest between the left carotid and subclavian arteries, and joins the left half of the deep part of the cardiac plexus.

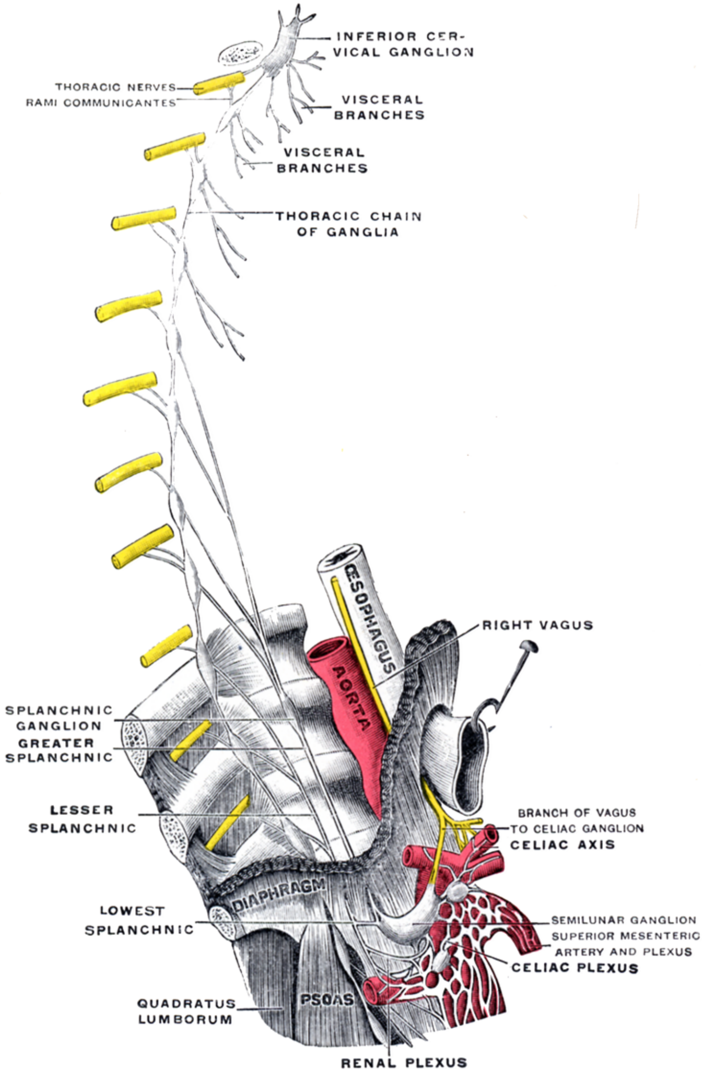


FIG. 845.—Plan of right sympathetic cord and splanchnic nerves. (Testut.)

Part XIII: The Lākshmikānta Shikshā correlated with the Cervico-thoracium (called inferior cervical ganglion in the book)

The **inferior cervical ganglion** (*ganglion cervicale inferius*) is situated between the base of the transverse process of the last cervical vertebra and the neck of the first rib, on the medial side of the costocervical artery. Its form is irregular; it is larger in size than the preceding, and is frequently fused with the first thoracic ganglion. It is probably formed by the coalescence of two ganglia which correspond to the seventh and eighth cervical nerves. It is connected to the middle

cervical ganglion by two or more cords, one of which forms a loop around the subclavian artery and supplies offsets to it. This loop is named the **ansa subclavia** (*Vieussenii*).

The ganglion sends gray rami communicantes to the seventh and eighth cervical nerves.

It gives off the inferior cardiac nerve, and offsets to bloodvessels.

The **inferior cardiac nerve** (*n. cardiacus inferior*) *arises* from either the inferior cervical or the first thoracic ganglion. It descends behind the subclavian artery and along the front of the trachea, to join the deep part of the cardiac plexus. It communicates freely behind the subclavian artery with the recurrent nerve and the middle cardiac nerve.

The **offsets to bloodvessels** form plexuses on the subclavian artery and its branches. The plexus on the vertebral artery is continued on to the basilar, posterior cerebral, and cerebellar arteries. The plexus on the inferior thyroid artery accompanies the artery to the thyroid gland, and communicates with the recurrent and external laryngeal nerves, with the superior cardiac nerve, and with the plexus on the common carotid artery.

Part XIV: The Shikshās of Shukla Yajur Veda correlated with the thoracic ganglia (pages 981-982)

THE THORACIC PORTION OF THE SYMPATHETIC SYSTEM (PARS THORACALIS S. SMYPATHICI) (Fig. 846).

The thoracic portion of the sympathetic trunk consists of a series of ganglia, which usually correspond in number to that of the vertebræ; but, on account of the occasional coalescence of two ganglia, their number is uncertain. The thoracic ganglia rest against the heads of the ribs, and are covered by the costal pleura; the last two, however, are more anterior than the rest, and are placed on the sides of the bodies of the eleventh and twelfth thoracic vertebræ. The ganglia are small in size, and of a grayish color. The first, larger than the others, is of an elongated form, and frequently blended with the inferior cervical ganglion. They are connected together by the intervening portions of the trunk.

Two rami communicantes, a white and a gray, connect each ganglion with its corresponding spinal nerve.

The *branches from the upper five ganglia* are very small; they supply filaments to the thoracic aorta and its branches. Twigs from the second, third, and fourth ganglia enter the posterior pulmonary plexus.

The *branches from the lower seven ganglia* are large, and white in color; they distribute filaments to the aorta, and unite to form the greater, the lesser, and the lowest splanchnic nerves.

The **greater splanchnic nerve** (*n. splanchnicus major; great splanchnic nerve*) is white in color, firm in texture, and of a considerable size; it is formed by branches from the fifth to the ninth or tenth thoracic ganglia, but the fibers in the higher roots may be traced upward in the sympathetic trunk as far as the first or second thoracic ganglion. It descends obliquely on the bodies of the vertebræ, perforates the crus of the diaphragm, and ends in the celiac ganglion. A ganglion (**ganglion splanchnicum**) exists on this nerve opposite the eleventh or twelfth thoracic vertebra.

The **lesser splanchnic nerve** (*n. splanchnicus minor*) is formed by filaments from the ninth and tenth, and sometimes the eleventh thoracic ganglia, and from the cord between them. It pierces the diaphragm with the preceding nerve, and joins the aorticorenal ganglion.

The **lowest splanchnic nerve** (*n. splanchnicus imus; least splanchnic nerve*) *arises* from the last thoracic ganglion, and, piercing the diaphragm, ends in the renal plexus.

A striking analogy exists between the splanchnic and the cardiac nerves. The cardiac nerves are three in number; they *arise* from all three cervical ganglia,

and are distributed to a large and important organ in the thoracic cavity. The splanchnic nerves, also three in number, are connected probably with all the thoracic ganglia, and are distributed to important organs in the abdominal cavity.

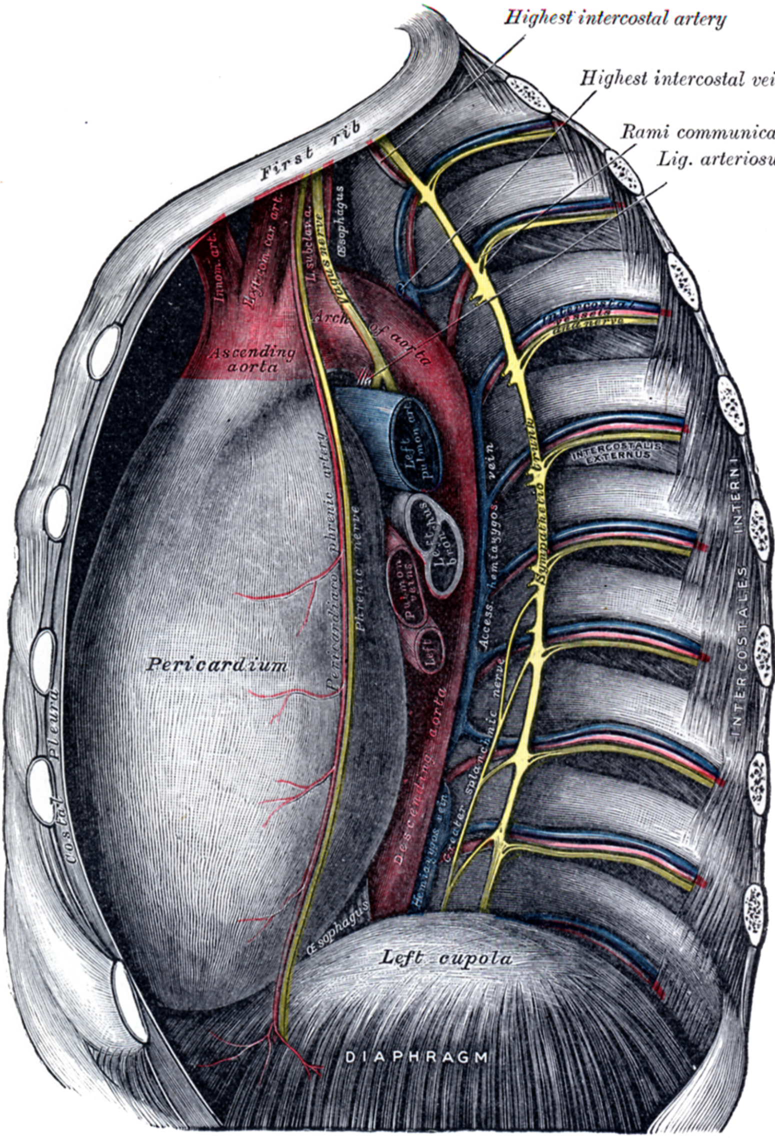


FIG. 846.—Thoracic portion of the sympathetic trunk.

Part XV: Siddhānta, Āpishali, Sarvasammata, Āranya and Shambhu Shikshās correlated with the lumbar ganglia

THE ABDOMINAL PORTION OF THE SYMPATHETIC SYSTEM (PARS ABDOMINALIS S. SYMPATHICI; LUMBAR PORTION OF GANGLIATED CORD) (Fig. 847).

The abdominal portion of the sympathetic trunk is situated in front of the vertebral column, along the medial margin of the Psoas major. It consists usually of four lumbar ganglia, connected together by interganglionic cords. It is continuous above with the thoracic portion beneath the medial lumbocostal arch, and below with the pelvic portion behind the common iliac artery. The ganglia are of small size, and placed much nearer the median line than are the thoracic ganglia.

Gray rami communicantes pass from all the ganglia to the lumbar spinal nerves. The first and second, and sometimes the third, lumbar nerves send white rami

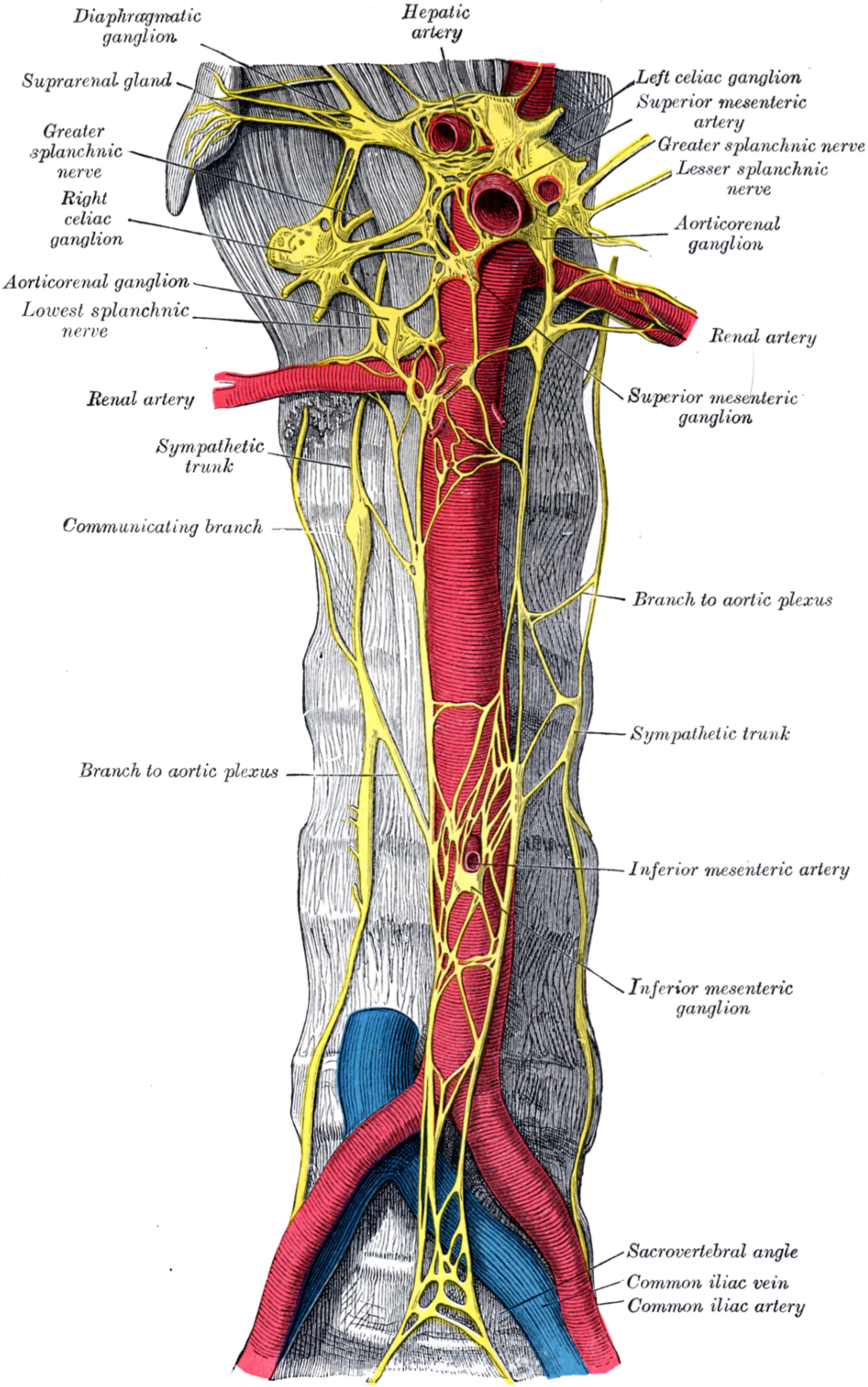


FIG. 847.—Abdominal portion of the sympathetic trunk, with the celiac and hypogastric plexuses. (Henle.)

communicantes to the corresponding ganglia. The rami communicantes are of considerable length, and accompany the lumbar arteries around the sides of the bodies of the vertebræ, passing beneath the fibrous arches from which some of the fibers of the Psoas major arise.

Of the **branches of distribution**, some pass in front of the aorta, and join the aortic plexus; others descend in front of the common iliac arteries, and assist in forming the hypogastric plexus.

Part XVI: Kālanirnaya, Bhāradvāja, Kauhalīya, Pāri, Shodashashlokī, Māndūkī, Nāradīya, Gautamī and Lomashī Shikshās correlated with the sacral ganglia

THE PELVIC PORTION OF THE SYMPATHETIC SYSTEM (PARS PELVINA S. SYMPATHICI).

The pelvic portion of each sympathetic trunk is situated in front of the sacrum, medial to the anterior sacral foramina. It consists of four or five small sacral ganglia, connected together by interganglionic cords, and continuous above with the abdominal portion. Below, the two pelvic sympathetic trunks converge, and end on the front of the coccyx in a small ganglion, the **ganglion impar.**

Gray rami communicantes pass from the ganglia to the sacral and coccygeal nerves. No white rami communicantes are given to this part of the gangliated cord, but the visceral branches which arise from the third and fourth, and sometimes from the second, sacral, and run directly to the pelvic plexuses, are regarded as white rami communicantes.

The **branches of distribution** communicate on the front of the sacrum with the corresponding branches from the opposite side; some, from the first two ganglia, pass to join the pelvic plexus, and others form a plexus, which accompanies the middle sacral artery and sends filaments to the **glomus coccygeum** (*coccygeal body*).

Part XVII: The autonomic ganglia in the context of the Sympathetic Nervous system

THE SYMPATHETIC NERVOUS SYSTEM.

The **sympathetic nervous system** (Fig. 838) innervates all the smooth muscles and the various glands of the body, and the striated muscle of the heart. The efferent sympathetic fibers which leave the central nervous system in connection with

certain of the cranial and spinal nerves all end in sympathetic ganglia and are known as **preganglionic fibers.** From these ganglia postganglionic fibers arise and

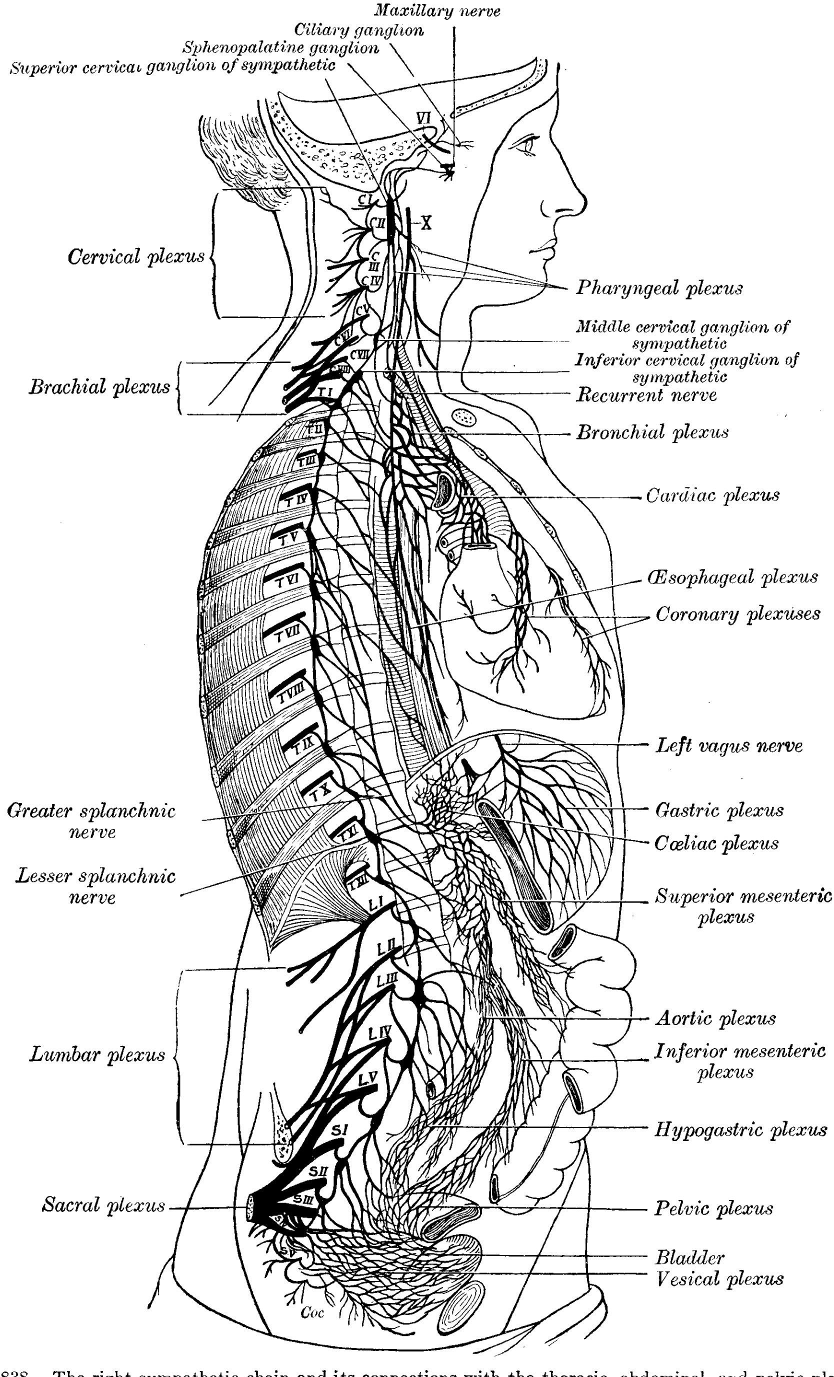


FIG 838.—The right sympathetic chain and its connections with the thoracic, abdominal, and pelvic plexuses. (After Schwalbe.)

conduct impulses to the different organs. In addition, afferent or sensory fibers connect many of these structures with the central nervous system.

The peripheral portion of the sympathetic nervous system is characterized by the presence of numerous ganglia and complicated plexuses. These ganglia are connected with the central nervous system by three groups of sympathetic efferent or preganglionic fibers, *i. e.*, the **cranial**, the **thoracolumbar**, and the **sacral**. These outflows of sympathetic fibers are separated by intervals where no connections exist. The cranial and sacral sympathetics are often grouped together owing to the resemblance between the reactions produced by stimulating them and by the effects of certain drugs. Acetyl-choline, for example, when injected intravenously in very small doses, produces the same effect as the stimulation of the cranial or sacral sympathetics, while the introduction of adrenalin produces the same effect as the stimulation of the thoracolumbar sympathetics. Much of our present knowledge of the sympathetic nervous system has been acquired through the application of various drugs, especially nicotine which paralyzes the connections or synapses between the preganglionic and postganglionic fibers of the sympathetic nerves. When it is injected into the general circulation all such synapses are paralyzed; when it is applied locally on a ganglion only the synapses occurring in that particular ganglion are paralyzed.

Langley,[1] who has contributed greatly to our knowledge, adopted a terminology somewhat different from that used here and still different from that used by the pharmacologists. This has led to considerable confusion, as shown by the arrangement of the terms in the following columns. Gaskell has used the term involuntary nervous system.[2]

Gray.	Langley.	Meyer and Gottlieb.[3]
Sympathetic nervous system.	Autonomic nervous system.	Vegetative nervous system.
Cranio-sacral sympathetics.	Parasympathetics.	Autonomic.
Oculomotor sympathetics.	Tectal autonomics.	Cranial autonomics.
Facial sympathetics. Glossopharyngeal sympathetics. Vagal sympathetics.	Bulbar autonomics.	
Sacral sympathetics.	Sacral autonomics.	Sacral autonomics.
Thoracolumbar sympathetics.	Sympathetic. Thoracic autonomic.	Sympathetic.
Enteric.	Enteric.	Enteric.

THE CRANIAL SYMPATHETICS.

The **cranial sympathetics** include sympathetic efferent fibers in the oculomotor, facial, glossopharyngeal and vagus nerves, as well as sympathetic afferent in the last three nerves.

The **Sympathetic Efferent Fibers of the Oculomotor Nerve** probably arise from cells in the anterior part of the oculomotor nucleus which is located in the tegmentum of the mid-brain. These preganglionic fibers run with the third nerve into the orbit and pass to the ciliary ganglion where they terminate by forming synapses with sympathetic motor neurons whose axons, postganglionic fibers, proceed as the short ciliary nerves to the eyeball. Here they supply motor fibers to the Ciliaris muscle and the Sphincter pupillæ muscle. So far as known there are no sympathetic afferent fibers connected with the nerve.

The **Sympathetic Efferent Fibers of the Facial Nerve** are supposed to arise from the small cells of the facial nucleus. According to some authors the fibers to the salivary glands arise from a special nucleus, the superior salivatory nucleus, consisting of cells scattered in the reticular formation, dorso-medial to the facial nucleus. These preganglionic fibers are distributed partly through the chorda tympani and

[1] Schäfer. Textbook of Physiology, 1900.
[2] Gaskell, W. H., The Involuntary Nervous System, London, 1916.
[3] Die Experimentelle Pharmakologie, 1910.

lingual nerves to the submaxillary ganglion where they terminate about the cell bodies of neurons whose axons as postganglionic fibers conduct secretory and vaso-

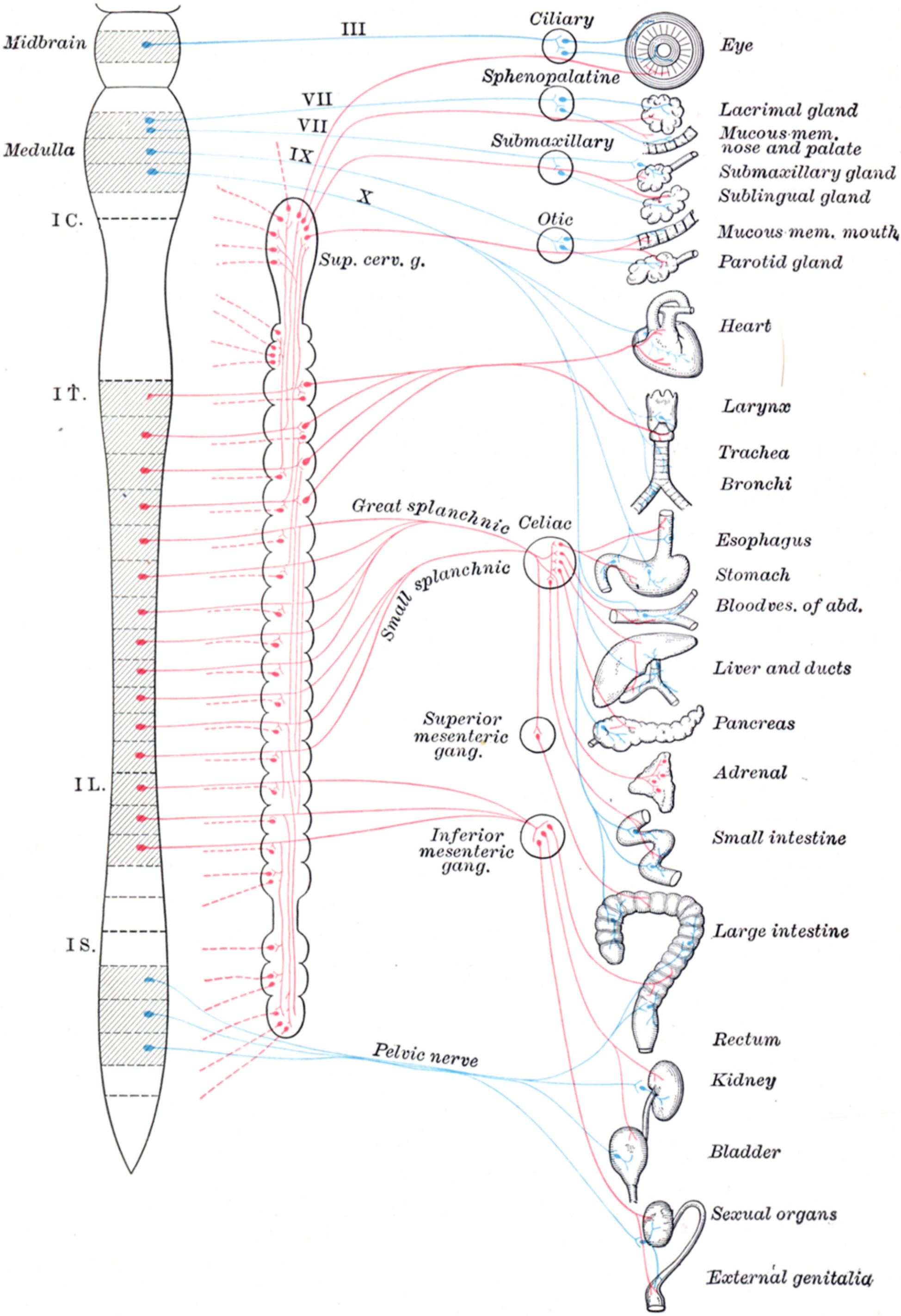


FIG. 839.—Diagram of efferent sympathetic nervous system. Blue, cranial and sacral outflow. Red, thoraco-humeral outflow. ------, Postganglionic fibers to spinal and cranial nerves to supply vasomotors to head, trunk and limbs, motor fibers to smooth muscles of skin and fibers to sweat glands. (Modified after Meyer and Gottlieb.)

dilator impulses to the submaxillary and sublingual glands. Other preganglionic fibers of the facial nerve pass via the great superficial petrosal nerve to the spheno-palatine ganglion where they form synapses with neurons whose postganglionic fibers are distributed with the superior maxillary nerve as vasodilator and secretory fibers to the mucous membrane of the nose, soft palate, tonsils, uvula, roof of the mouth, upper lips and gums, parotid and orbital glands.

There are supposed to be a few sympathetic afferent fibers connected with the facial nerve, whose cell bodies lie in the geniculate ganglion, but very little is known about them.

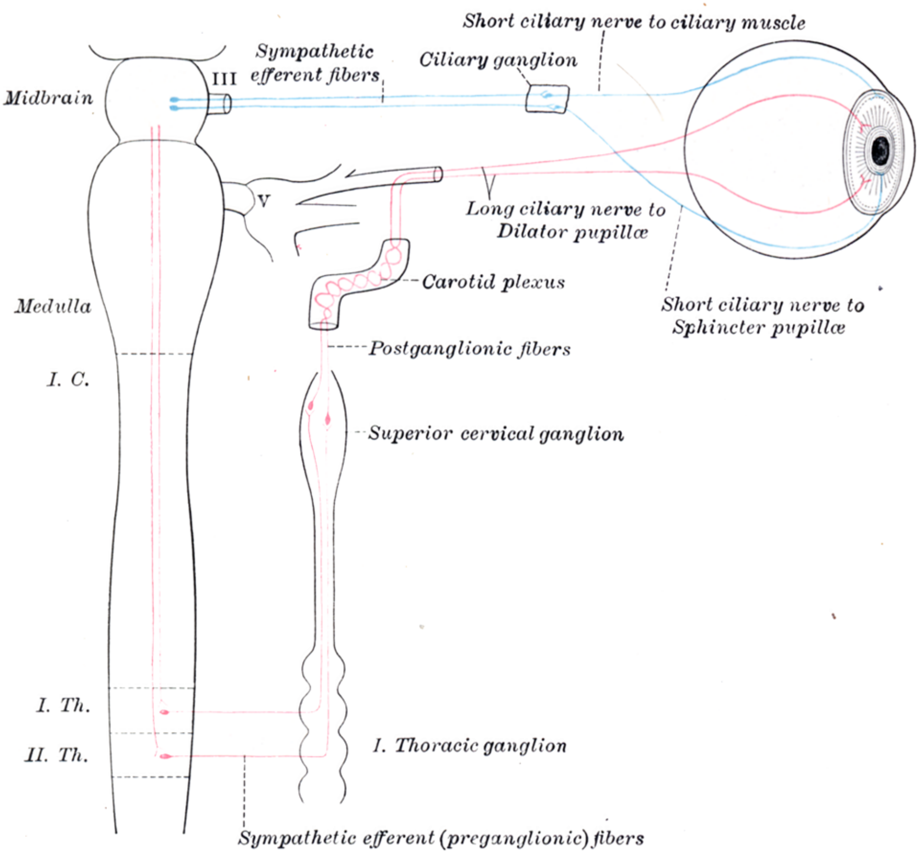


FIG. 840.—Sympathetic connections of the ciliary and superior cervical ganglia.

The **Sympathetic Afferent Fibers of the Glossopharyngeal Nerve** are supposed to arise either in the dorsal nucleus (nucleus ala cinerea) or in a distinct nucleus, the inferior salivatory nucleus, situated near the dorsal nucleus. These preganglionic fibers pass into the tympanic branch of the glossopharyngeal and then with the small superficial petrosal nerve to the otic ganglion. Postganglionic fibers, vasodilator and secretory fibers, are distributed to the parotid gland, to the mucous membrane and its glands on the tongue, the floor of the mouth, and the lower gums.

Sympathetic Afferent Fibers, whose cells of origin lie in the superior or inferior ganglion of the trunk, are supposed to terminate in the dorsal nucleus. Very little is known of the peripheral distribution of these fibers.

The **Sympathetic Efferent Fibers of the Vagus Nerve** are supposed to arise in the dorsal nucleus (nucleus ala cinerea). These preganglionic fibers are all supposed to end in sympathetic ganglia situated in or near the organs supplied by the vagus sym-

pathetics. The inhibitory fibers to the heart probably terminate in the small ganglia of the heart wall especially the atrium, from which inhibitory postganglionic fibers are distributed to the musculature. The preganglionic motor fibers to the esophagus, the stomach, the small intestine, and the greater part of the large intestine are supposed to terminate in the plexuses of Auerbach, from which postganglionic fibers are distributed to the smooth muscles of these organs. Other fibers pass to the smooth muscles of the bronchial tree and to the gall-bladder and its ducts. In addition the vagus is believed to contain secretory fibers to the stomach and pancreas. It probably contains many other efferent fibers than those enumerated above.

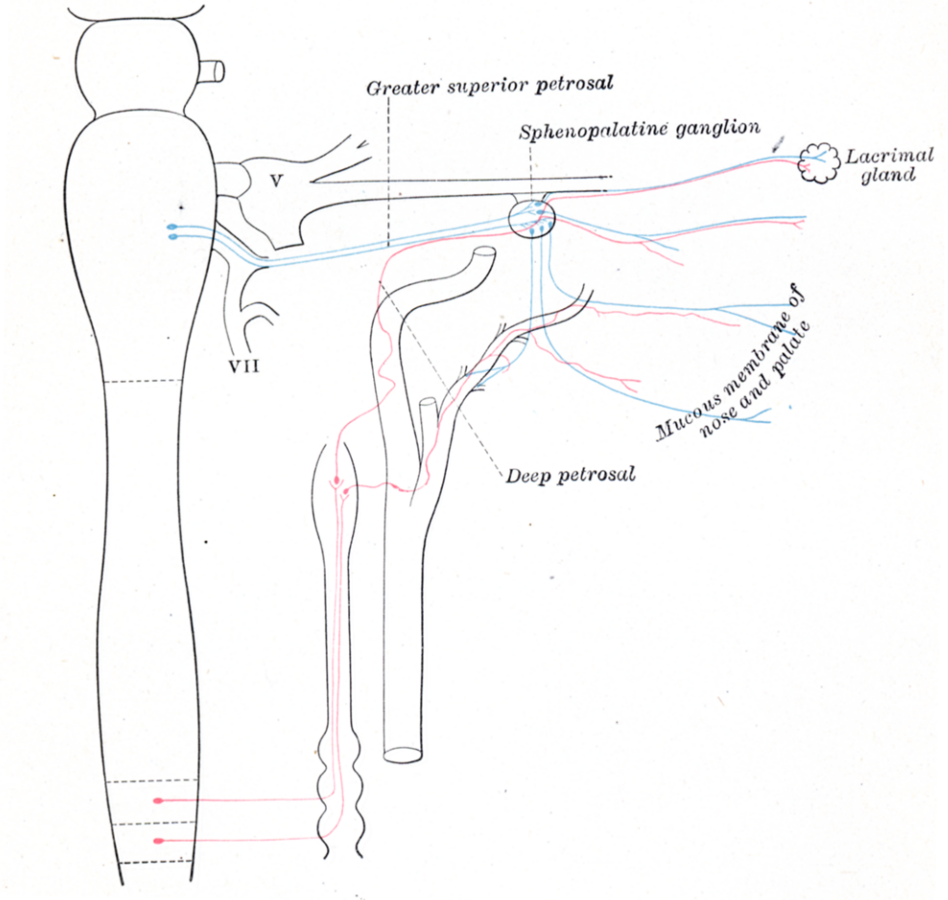


FIG. 841.—Sympathetic connections of the sphenopalatine and superior cervical ganglia.

Sympathetic Afferent Fibers of the Vagus, whose cells of origin lie in the jugular ganglion or the ganglion nodosum, probably terminate in the dorsal nucleus of the medulla oblongata or according to some authors in the nucleus of the tractus solitarius. Peripherally the fibers are supposed to be distributed to the various organs supplied by the sympathetic efferent fibers.

THE SACRAL SYMPATHETICS.

The **Sacral Sympathetic Efferent Fibers** leave the spinal cord with the anterior roots of the second, third and fourth sacral nerves. These small medullated preganglionic fibers are collected together in the pelvis into the nervus erigentes or pelvic nerve

which proceeds to the hypogastric or pelvic plexuses from which postganglionic fibers are distributed to the pelvic viscera. Motor fibers pass to the smooth muscle of the descending colon, rectum, anus and bladder. Vasodilators are distributed to these organs and to the external genitalia, while inhibitory fibers probably pass to the smooth muscles of the external genitalia. **Afferent sympathetic fibers** conduct impulses from the pelvic viscera to the second, third and fourth sacral nerves. Their cells of origin lie in the spinal ganglia.

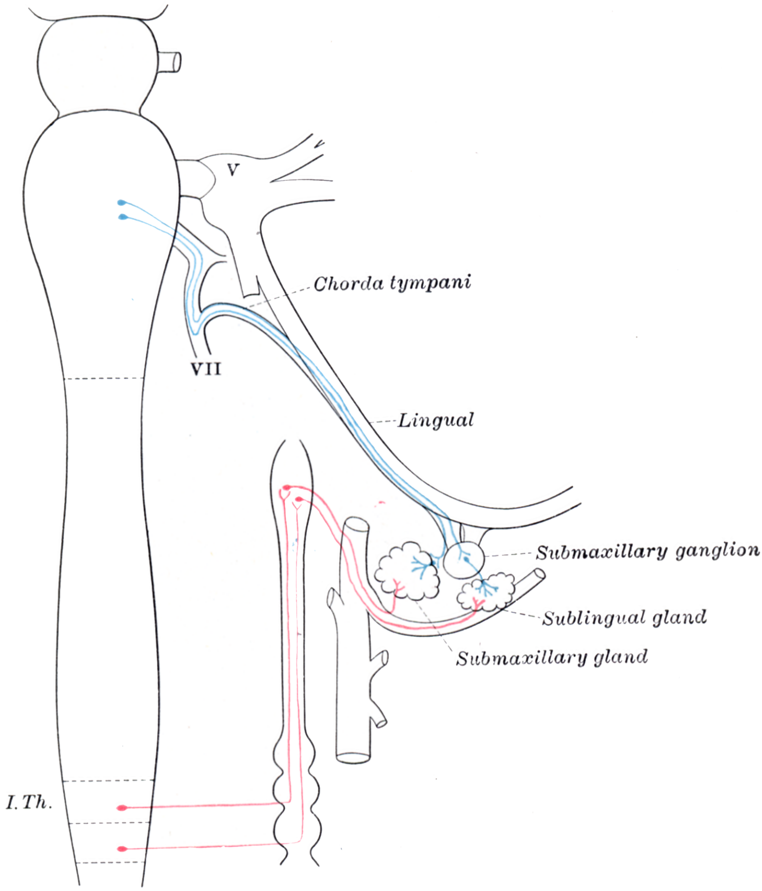


Fig. 842.—Sympathetic connections of the submaxillary and superior cervical ganglia.

THE THORACOLUMBAR SYMPATHETICS.

The **thoracolumbar sympathetic fibers** arise from the dorso-lateral region of the anterior column of the gray matter of the spinal cord and pass with the anterior roots of all the thoracic and the upper two or three lumbar spinal nerves. These preganglionic fibers enter the white rami communicantes and proceed to the sympathetic trunk where many of them end in its ganglia, others pass to the prevertebral plexuses and terminate in its collateral ganglia. The postganglionic fibers have a wide distribution. The **vasoconstrictor fibers** to the bloodvessels of the skin of the trunk and limbs, for example, leave the spinal cord as preganglionic fibers in all the thoracic and the upper two or three lumbar spinal nerves and terminate in the ganglia of the sympathetic trunk, either in the ganglion directly connected with its ramus or in neighboring ganglia. Postganglionic fibers arise

in these ganglia, pass through gray rami communicantes to all the spinal nerves, and are distributed with their cutaneous branches, ultimately leaving these branches to join the small arteries. The postganglionic fibers do not necessarily return to the same spinal nerves which contain the corresponding preganglionic fibers. The vasoconstrictor fibers to the head come from the upper thoracic nerves, the preganglionic fibers end in the superior cervical ganglion. The postganglionic fibers pass through the internal carotid nerve and branch from it to join the sensory branches of the various cranial nerves, especially the trigeminal nerve; other fibers to the deep structures and the salivary glands probably accompany the arteries.

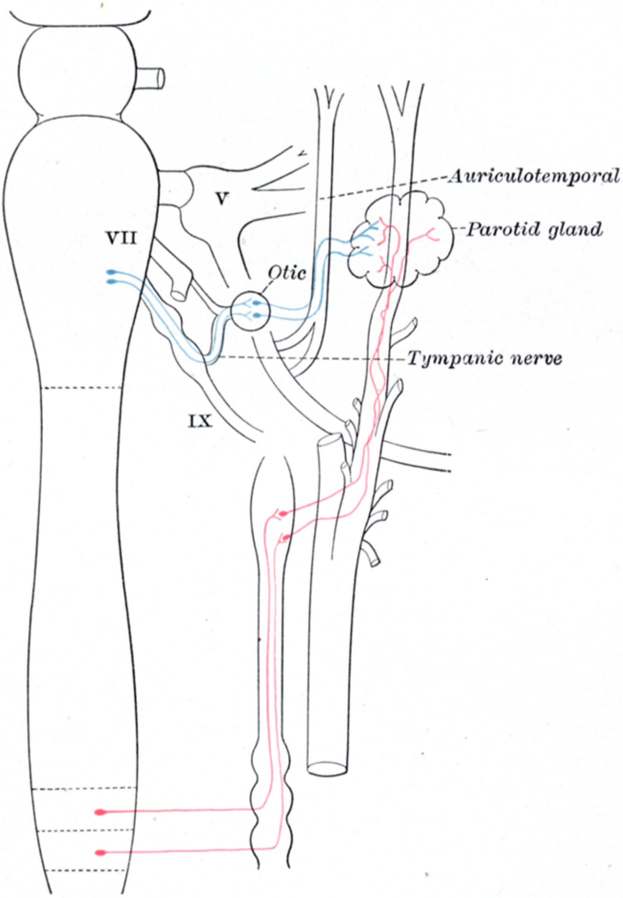


FIG. 843.—Sympathetic connections of the otic and superior cervical ganglia.

The postganglionic vasoconstrictor fibers to the bloodvessels of the abdominal viscera arise in the prevertebral or collateral ganglia in which terminate many preganglionic fibers. Vasoconstrictor fibers to the pelvic viscera arise from the inferior mesenteric ganglia.

The pilomotor fibers to the hairs and the motor fibers to the sweat glands apparently have a distribution similar to that of the vasoconstrictors of the skin.

A vasoconstrictor center has been located by the physiologists in the neighborhood of the facial nucleus. Axons from its cells are supposed to descend in the spinal cord to terminate about cell bodies of the preganglionic fibers located in the dorsolateral portion of the anterior column of the thoracic and upper lumbar region.

The motor supply to the dilator pupillæ muscle of the eye comes from pregan-

glionic sympathetic fibers which leave the spinal cord with the anterior roots of the upper thoracic nerves. These fibers pass to the sympathetic trunk through the white rami communicantes and terminate in the superior cervical ganglion. Postganglionic fibers from the superior cervical ganglion pass through the internal carotid nerve and the ophthalmic division of the trigeminal nerve to the orbit where the long ciliary nerves conduct the impulses to the eyeball and the dilator pupillæ muscle. The cell bodies of these preganglionic fibers are connected with fibers which descend from the mid-brain.

Other postganglionic fibers from the superior cervical ganglion are distributed as secretory fibers to the salivary glands, the lacrimal glands and to the small glands of the mucous membrane of the nose, mouth and pharynx.

The thoracic sympathetics supply accelerator nerves to the heart. They are supposed to emerge from the spinal cord in the anterior roots of the upper four or five thoracic nerves and pass with the white rami to the first thoracic ganglion, here some terminate, others pass in the ansa subclavia to the inferior cervical ganglion. The postganglionic fibers pass from these ganglia partly through the ansa subclavia to the heart, on their way they intermingle with sympathetic fibers from the vagus to form the cardiac plexus.

Inhibitory fibers to the smooth musculature of the stomach, the small intestine and most of the large intestine are supposed to emerge in the anterior roots of the lower thoracic and upper lumbar nerves. These fibers pass through the white rami and sympathetic trunk and are conveyed by the splanchnic nerves to the prevertebral plexus where they terminate in the collateral ganglia. From the celiac and superior mesenteric ganglia postganglionic fibers (inhibitory) are distributed to the stomach, the small intestine and most of the large intestine. Inhibitory fibers to the descending colon, the rectum and Internal sphincter ani are probably postganglionic fibers from the inferior mesenteric ganglion.

The thoracolumbar sympathetics are characterized by the presence of numerous ganglia which may be divided into two groups, **central** and **collateral.**

The **central ganglia** are arranged in two vertical rows, one on either side of the middle line, situated partly in front and partly at the sides of the vertebral column. Each ganglion is joined by intervening nervous cords to adjacent ganglia so that two chains, the **sympathetic trunks,** are formed. The **collateral ganglia** are found in connection with three great **prevertebral plexuses,** placed within the thorax, abdomen, and pelvis respectively.

The **sympathetic trunks** (*truncus sympathicus; gangliated cord*) extend from the base of the skull to the coccyx. The cephalic end of each is continued upward through the carotid canal into the skull, and forms a plexus on the internal carotid artery; the caudal ends of the trunks converge and end in a single ganglion, the **ganglion impar,** placed in front of the coccyx. The ganglia of each trunk are distinguished as **cervical, thoracic, lumbar,** and **sacral** and, except in the neck, they closely correspond in number to the vertebræ. They are arranged thus:

Cervical portion	3 ganglia
Thoracic "	12 "
Lumbar "	4 "
Sacral "	4 or 5 "

In the neck the ganglia lie in front of the transverse processes of the vertebræ; **in the thoracic region** in front of the heads of the ribs; **in the lumbar region** on the sides of the vertebral bodies; and **in the sacral region** in front of the sacrum.

Connections with the Spinal Nerves.—Communications are established between the sympathetic and spinal nerves through what are known as the **gray** and **white rami communicantes** (Fig. 799); the gray rami convey sympathetic fibers into the spinal nerves and the white rami transmit spinal fibers into the sympathetic.

Each spinal nerve receives a gray ramus communicans from the sympathetic trunk, but white rami are not supplied by all the spinal nerves. White rami are derived from the first thoracic to the first lumbar nerves inclusive, while the visceral branches which run from the second, third, and fourth sacral nerves directly to the pelvic plexuses of the sympathetic belong to this category. The fibers which reach the sympathetic through the white rami communicantes are medullated; those which spring from the cells of the sympathetic ganglia are almost entirely non-medullated. The sympathetic nerves consist of efferent and afferent fibers, the origin and course of which are described on page 920).

The **three great gangliated plexuses** (*collateral ganglia*) are situated in front of the vertebral column in the thoracic, abdominal, and pelvic regions, and are named, respectively, the **cardiac,** the **solar** or **epigastric,** and the **hypogastric plexuses.** They consist of collections of nerves and ganglia; the nerves being derived from the sympathetic trunks and from the cerebrospinal nerves. They distribute branches to the viscera.

Development.—The ganglion cells of the sympathetic system are derived from the cells of the neural crests. As these crests move forward along the sides of the neural tube and become segmented off to form the spinal ganglia, certain cells detach themselves from the ventral margins of the crests and migrate toward the sides of the aorta, where some of them are grouped to form the ganglia of the sympathetic trunks, while others undergo a further migration and form the ganglia of the prevertebral and visceral plexuses. The ciliary, sphenopalatine, otic, and submaxillary ganglia which are found on the branches of the trigeminal nerve are formed by groups of cells which have migrated from the part of the neural crest which gives rise to the semilunar ganglion. Some of the cells of the ciliary ganglion are said to migrate from the neural tube along the oculomotor nerve.

THE CEPHALIC PORTION OF THE SYMPATHETIC SYSTEM (PARS CEPHALICA S. SYMPATHICI).

The **cephalic portion** of the sympathetic system begins as the **internal carotid nerve,** which appears to be a direct prolongation of the superior cervical ganglion. It is soft in texture, and of a reddish color. It ascends by the side of the internal carotid artery, and, entering the carotid canal in the temporal bone, divides into two branches, which lie one on the lateral and the other on the medial side of that vessel.

The **lateral branch,** the larger of the two, distributes filaments to the internal carotid artery, and forms the **internal carotid plexus.**

The **medial branch** also distributes filaments to the internal carotid artery, and, continuing onward, forms the **cavernous plexus.**

The **internal carotid plexus** (*plexus caroticus internus; carotid plexus*) is situated on the lateral side of the internal carotid artery, and in the plexus there occasionally exists a small gangliform swelling, the **carotid ganglion,** on the under surface of the artery. The internal carotid plexus communicates with the semilunar ganglion, the abducent nerve, and the sphenopalatine ganglion; it distributes filaments to the wall of the carotid artery, and also communicates with the tympanic branch of the glossopharyngeal nerve.

The communicating branches with the abducent nerve consist of one or two filaments which join that nerve as it lies upon the lateral side of the internal carotid artery. The communication with the sphenopalatine ganglion is effected by a branch, the **deep petrosal,** given off from the plexus on the lateral side of the artery; this branch passes through the cartilage filling up the foramen lacerum, and joins the greater superficial petrosal to form the nerve of the pterygoid canal (*Vidian nerve*), which passes through the pterygoid canal to the sphenopalatine ganglion.

The communication with the tympanic branch of the glossopharyngeal nerve is effected by the **caroticotympanic,** which may consist of two or three delicate filaments.

The **cavernous plexus** (*plexus cavernosus*) is situated below and medial to that part of the internal carotid artery which is placed by the side of the sella turcica in the cavernous sinus, and is formed chiefly by the medial division of the internal carotid nerve. It communicates with the oculomotor, the trochlear, the ophthalmic and the abducent nerves, and with the ciliary ganglion, and distributes filaments to the wall of the internal carotid artery. The branch of communication with the oculomotor nerve joins that nerve at its point of division; the branch to the trochlear nerve joins it as it lies on the lateral wall of the cavernous sinus; other filaments are connected with the under surface of the ophthalmic nerve; and a second filament joins the abducent nerve.

The **filaments of connection** with the ciliary ganglion *arise* from the anterior part of the cavernous plexus and enter the orbit through the superior orbital fissure; they may join the nasociliary branch of the ophthalmic nerve, or be continued forward as a separate branch.

The **terminal filaments** from the internal carotid and cavernous plexuses are prolonged as plexuses around the anterior and middle cerebral arteries and the ophthalmic artery; along the former vessels, they may be traced to the pia mater; along the latter, into the orbit, where they accompany each of the branches of the vessel. The filaments prolonged on to the anterior communicating artery connect the sympathetic nerves of the right and left sides.

THE CERVICAL PORTION OF THE SYMPATHETIC SYSTEM (PARS CERVICALIS S. SYMPATHICI).

The **cervical portion** of the sympathetic trunk consists of three ganglia, distinguished, according to their positions, as the **superior, middle,** and **inferior ganglia,** connected by intervening cords. This portion receives no white rami communicantes from the cervical spinal nerves; its spinal fibers are derived from the white rami of the upper thoracic nerves, and enter the corresponding thoracic ganglia of the sympathetic trunk, through which they ascend into the neck.

The **superior cervical ganglion** (*ganglion cervicale superius*), the largest of the three, is placed opposite the second and third cervical vertebræ. It is of a reddish-gray color, and usually fusiform in shape; sometimes broad and flattened, and occasionally constricted at intervals; it is believed to be formed by the coalescence of four ganglia, corresponding to the upper four cervical nerves. It is in relation, in *front,* with the sheath of the internal carotid artery and internal jugular vein; *behind,* with the Longus capitis muscle.

Its **branches** may be divided into **inferior, lateral, medial,** and **anterior.**

The **Inferior Branch** communicates with the middle cervical ganglion.

The **Lateral Branches** (*external branches*) consist of gray rami communicantes to the upper four cervical nerves and to certain of the cranial nerves. Sometimes the branch to the fourth cervical nerve may come from the trunk connecting the upper and middle cervical ganglia. The branches to the cranial nerves consist of delicate filaments, which run to the ganglion nodosum of the vagus, and to the hypoglossal nerve. A filament, the **jugular nerve,** passes upward to the base of the skull, and divides to join the petrous ganglion of the glossopharyngeal, and the jugular ganglion of the vagus.

The **Medial Branches** (*internal branches*) are peripheral, and are the **larnygopharyngeal branches** and the **superior cardiac nerve.**

The **laryngopharyngeal branches** (*rami laryngopharyngei*) pass to the side of the

pharynx, where they join with branches from the glossopharyngeal, vagus, and external laryngeal nerves to form the **pharyngeal plexus.**

The **superior cardiac nerve** (*n. cardiacus superior*) *arises* by two or more branches from the superior cervical ganglion, and occasionally receives a filament from the trunk between the first and second cervical ganglia. It runs down the neck behind the common carotid artery, and in front of the Longus colli muscle; and crosses in front of the inferior thyroid artery, and recurrent nerve. The course of the nerves on the two sides then differ. The **right nerve,** at the root of the neck, passes either in front of or behind the subclavian artery, and along the innominate artery to the back of the arch of the aorta, where it joins the deep part of the cardiac plexus. It is connected with other branches of the sympathetic; about the middle of the neck it receives filaments from the external laryngeal nerve; lower down, one or two twigs from the vagus; and as it enters the thorax it is joined by a filament from the recurrent nerve. Filaments from the nerve communicate with the thyroid branches from the middle cervical ganglion. The **left nerve,** in the thorax, runs in front of the left common carotid artery and across the left side of the arch of the aorta, to the superficial part of the cardiac plexus.

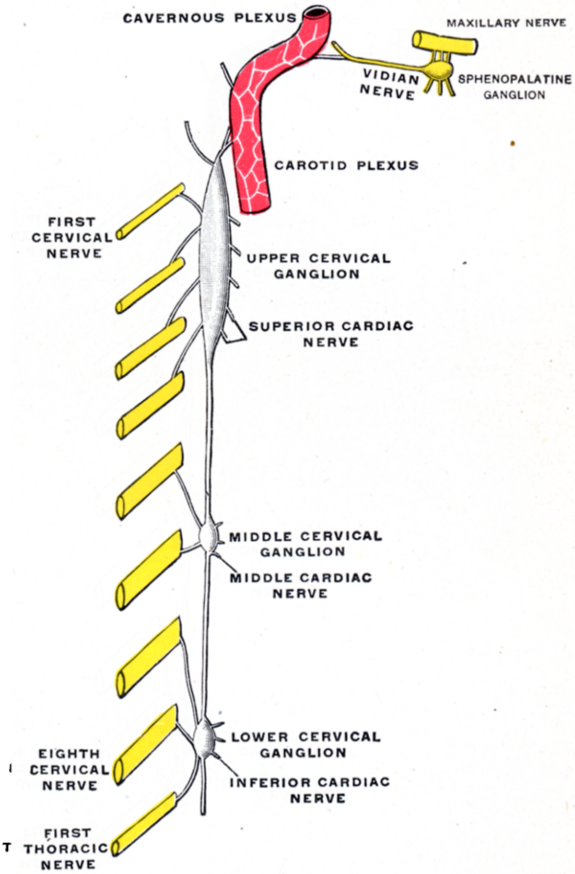


FIG. 844.—Diagram of the cervical sympathetic. (Testut.)

The **Anterior Branches** (*nn. carotici externi*) ramify upon the common carotid artery and upon the external carotid artery and its branches, forming around each a delicate plexus, on the nerves composing which small ganglia are occasionally found. The plexuses accompanying some of these arteries have important communications with other nerves. That surrounding the external maxillary artery communicates with the submaxillary ganglion by a filament; and that accompanying the middle meningeal artery sends an offset to the otic ganglion, and a second, the **external petrosal nerve,** to the genicular ganglion of the facial nerve.

The **middle cervical ganglion** (*ganglion cervicale medium*) is the smallest of the three cervical ganglia, and is occasionally wanting. It is placed opposite the sixth cervical vertebra, usually in front of, or close to, the inferior thyroid artery. It is probably formed by the coalescence of two ganglia corresponding to the fifth and sixth cervical nerves.

It sends gray rami communicantes to the fifth and sixth cervical nerves, and gives off the middle cardiac nerve.

The **Middle Cardiac Nerve** (*n. cardiacus medius; great cardiac nerve*), the largest

of the three cardiac nerves, *arises* from the middle cervical ganglion, or from the trunk between the middle and inferior ganglia. On the right side it descends behind the common carotid artery, and at the root of the neck runs either in front of or behind the subclavian artery; it then descends on the trachea, receives a few filaments from the recurrent nerve, and joins the right half of the deep part of the cardiac plexus. In the neck, it communicates with the superior cardiac and recurrent nerves. On the left side, the middle cardiac nerve enters the chest between the left carotid and subclavian arteries, and joins the left half of the deep part of the cardiac plexus.

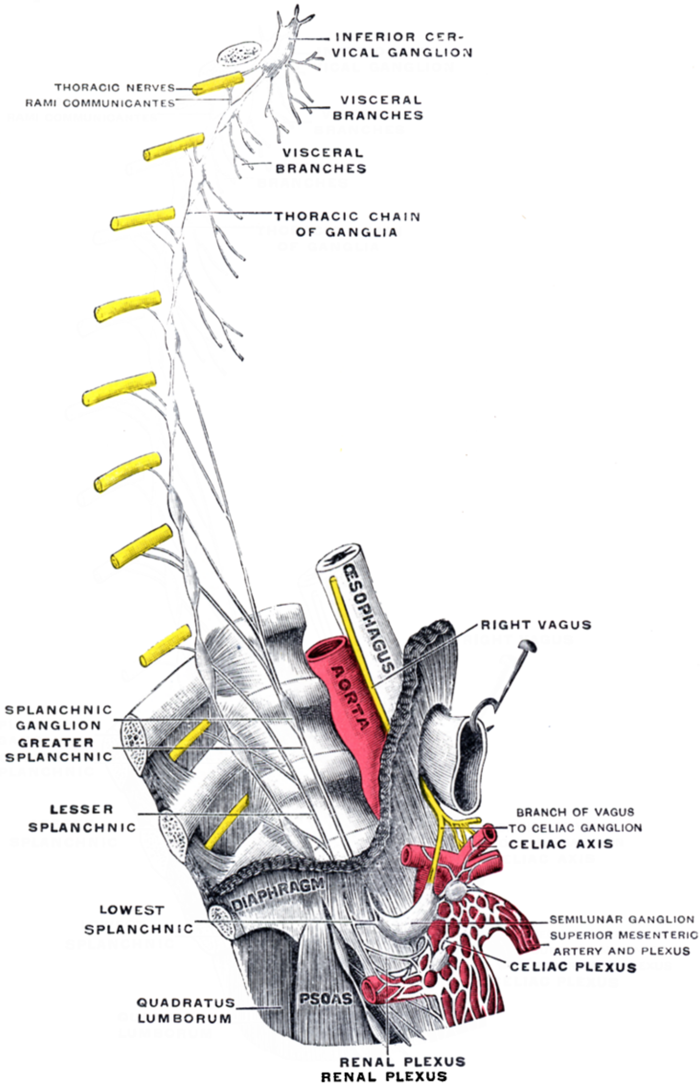


FIG. 845.—Plan of right sympathetic cord and splanchnic nerves. (Testut.)

The **inferior cervical ganglion** (*ganglion cervicale inferius*) is situated between the base of the transverse process of the last cervical vertebra and the neck of the first rib, on the medial side of the costocervical artery. Its form is irregular; it is larger in size than the preceding, and is frequently fused with the first thoracic ganglion. It is probably formed by the coalescence of two ganglia which correspond to the seventh and eighth cervical nerves. It is connected to the middle

cervical ganglion by two or more cords, one of which forms a loop around the subclavian artery and supplies offsets to it. This loop is named the **ansa subclavia** (*Vieussenii*).

The ganglion sends gray rami communicantes to the seventh and eighth cervical nerves.

It gives off the inferior cardiac nerve, and offsets to bloodvessels.

The **inferior cardiac nerve** (*n. cardiacus inferior*) *arises* from either the inferior cervical or the first thoracic ganglion. It descends behind the subclavian artery and along the front of the trachea, to join the deep part of the cardiac plexus. It communicates freely behind the subclavian artery with the recurrent nerve and the middle cardiac nerve.

The **offsets to bloodvessels** form plexuses on the subclavian artery and its branches. The plexus on the vertebral artery is continued on to the basilar, posterior cerebral, and cerebellar arteries. The plexus on the inferior thyroid artery accompanies the artery to the thyroid gland, and communicates with the recurrent and external laryngeal nerves, with the superior cardiac nerve, and with the plexus on the common carotid artery.

THE THORACIC PORTION OF THE SYMPATHETIC SYSTEM (PARS THORACALIS S. SMYPATHICI) (Fig. 846).

The thoracic portion of the sympathetic trunk consists of a series of ganglia, which usually correspond in number to that of the vertebræ; but, on account of the occasional coalescence of two ganglia, their number is uncertain. The thoracic ganglia rest against the heads of the ribs, and are covered by the costal pleura; the last two, however, are more anterior than the rest, and are placed on the sides of the bodies of the eleventh and twelfth thoracic vertebræ. The ganglia are small in size, and of a grayish color. The first, larger than the others, is of an elongated form, and frequently blended with the inferior cervical ganglion. They are connected together by the intervening portions of the trunk.

Two rami communicantes, a white and a gray, connect each ganglion with its corresponding spinal nerve.

The *branches from the upper five ganglia* are very small; they supply filaments to the thoracic aorta and its branches. Twigs from the second, third, and fourth ganglia enter the posterior pulmonary plexus.

The *branches from the lower seven ganglia* are large, and white in color; they distribute filaments to the aorta, and unite to form the greater, the lesser, and the lowest splanchnic nerves.

The **greater splanchnic nerve** (*n. splanchnicus major; great splanchnic nerve*) is white in color, firm in texture, and of a considerable size; it is formed by branches from the fifth to the ninth or tenth thoracic ganglia, but the fibers in the higher roots may be traced upward in the sympathetic trunk as far as the first or second thoracic ganglion. It descends obliquely on the bodies of the vertebræ, perforates the crus of the diaphragm, and ends in the celiac ganglion. A ganglion (**ganglion splanchnicum**) exists on this nerve opposite the eleventh or twelfth thoracic vertebra.

The **lesser splanchnic nerve** (*n. splanchnicus minor*) is formed by filaments from the ninth and tenth, and sometimes the eleventh thoracic ganglia, and from the cord between them. It pierces the diaphragm with the preceding nerve, and joins the aorticorenal ganglion.

The **lowest splanchnic nerve** (*n. splanchnicus imus; least splanchnic nerve*) *arises* from the last thoracic ganglion, and, piercing the diaphragm, ends in the renal plexus.

A striking analogy exists between the splanchnic and the cardiac nerves. The cardiac nerves are three in number; they *arise* from all three cervical ganglia,

and are distributed to a large and important organ in the thoracic cavity. The splanchnic nerves, also three in number, are connected probably with all the thoracic ganglia, and are distributed to important organs in the abdominal cavity.

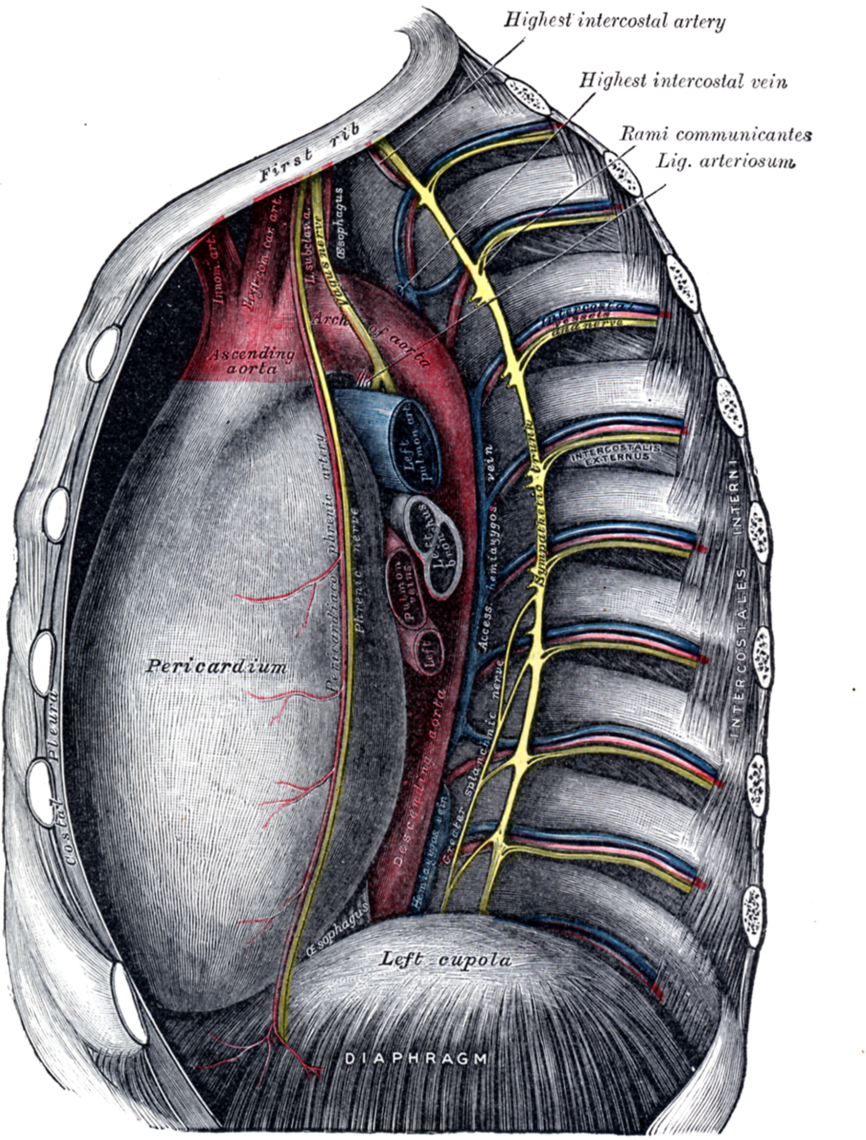


FIG. 846.—Thoracic portion of the sympathetic trunk.

THE ABDOMINAL PORTION OF THE SYMPATHETIC SYSTEM (PARS ABDOMINALIS S. SYMPATHICI; LUMBAR PORTION OF GANGLIATED CORD) (Fig. 847).

The abdominal portion of the sympathetic trunk is situated in front of the vertebral column, along the medial margin of the Psoas major. It consists usually of four lumbar ganglia, connected together by interganglionic cords. It is continuous above with the thoracic portion beneath the medial lumbocostal arch, and below with the pelvic portion behind the common iliac artery. The ganglia are of small size, and placed much nearer the median line than are the thoracic ganglia.

Gray rami communicantes pass from all the ganglia to the lumbar spinal nerves. The first and second, and sometimes the third, lumbar nerves send white rami

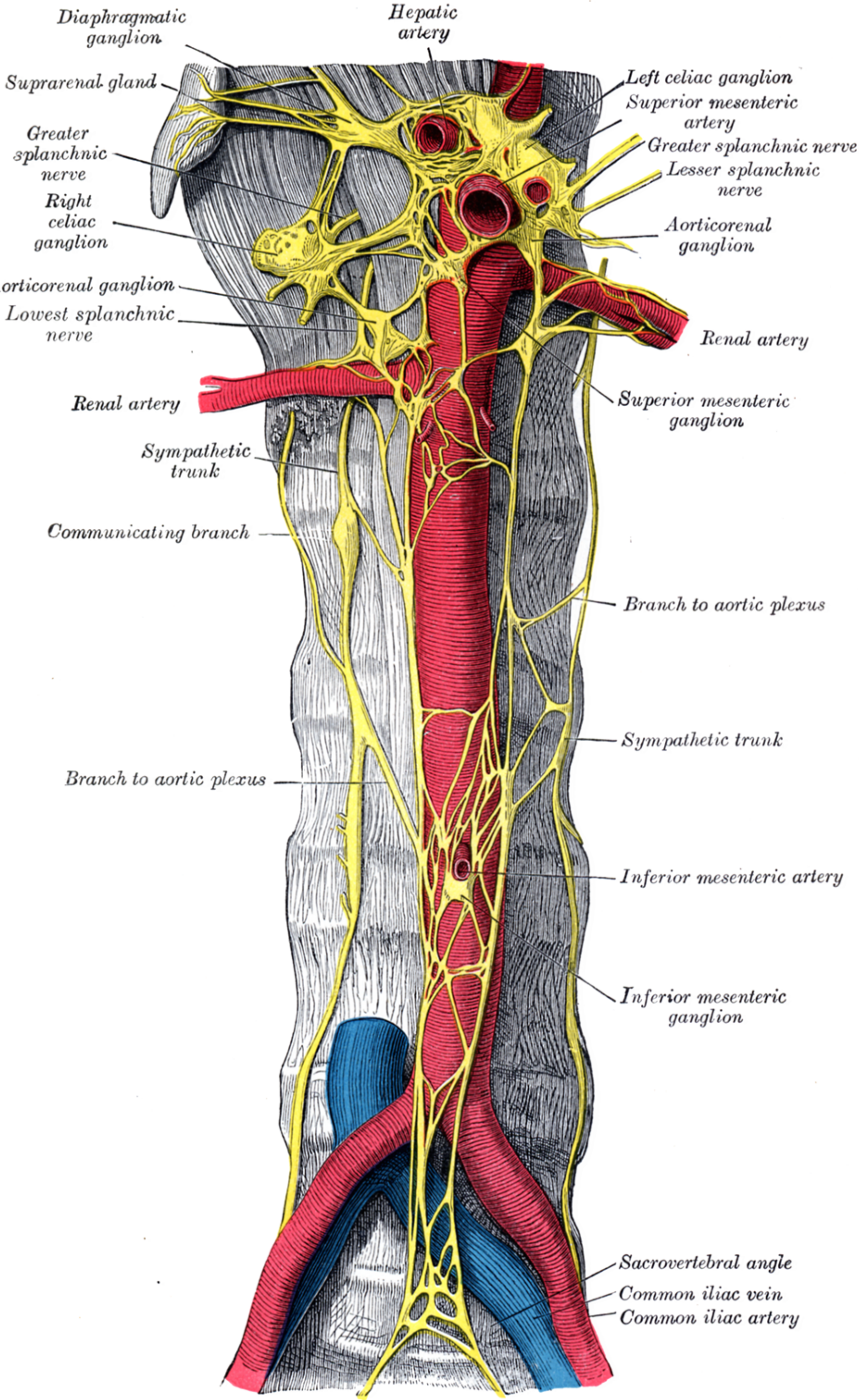


Fig. 847.—Abdominal portion of the sympathetic trunk, with the celiac and hypogastric plexuses. (Henle.)

communicantes to the corresponding ganglia. The rami communicantes are of considerable length, and accompany the lumbar arteries around the sides of the bodies of the vertebræ, passing beneath the fibrous arches from which some of the fibers of the Psoas major arise.

Of the **branches of distribution**, some pass in front of the aorta, and join the aortic plexus; others descend in front of the common iliac arteries, and assist in forming the hypogastric plexus.

THE PELVIC PORTION OF THE SYMPATHETIC SYSTEM (PARS PELVINA S. SYMPATHICI).

The pelvic portion of each sympathetic trunk is situated in front of the sacrum, medial to the anterior sacral foramina. It consists of four or five small sacral ganglia, connected together by interganglionic cords, and continuous above with the abdominal portion. Below, the two pelvic sympathetic trunks converge, and end on the front of the coccyx in a small ganglion, the **ganglion impar.**

Gray rami communicantes pass from the ganglia to the sacral and coccygeal nerves. No white rami communicantes are given to this part of the gangliated cord, but the visceral branches which arise from the third and fourth, and sometimes from the second, sacral, and run directly to the pelvic plexuses, are regarded as white rami communicantes.

The **branches of distribution** communicate on the front of the sacrum with the corresponding branches from the opposite side; some, from the first two ganglia, pass to join the pelvic plexus, and others form a plexus, which accompanies the middle sacral artery and sends filaments to the **glomus coccygeum** (*coccygeal body*).

THE GREAT PLEXUSES OF THE SYMPATHETIC SYSTEM.

The great plexuses of the sympathetic are aggregations of nerves and ganglia, situated in the thoracic, abdominal, and pelvic cavities, and named the **cardiac, celiac,** and **hypogastric plexuses.** They consist not only of sympathetic fibers derived from the ganglia, but of fibers from the medulla spinalis, which are conveyed through the white rami communicantes. From the plexuses branches are given to the thoracic, abdominal, and pelvic viscera.

The Cardiac Plexus (Plexus Cardiacus) (Fig. 838).

The **cardiac plexus** is situated at the base of the heart, and is divided into a **superficial part,** which lies in the concavity of the aortic arch, and a **deep part,** between the aortic arch and the trachea. The two parts are, however, closely connected.

The **superficial part of the cardiac plexus** lies beneath the arch of the aorta, in front of the right pulmonary artery. It is formed by the superior cardiac branch of the left sympathetic and the lower superior cervical cardiac branch of the left vagus. A small ganglion, the **cardiac ganglion of Wrisberg,** is occasionally found connected with these nerves at their point of junction. This ganglion, when present, is situated immediately beneath the arch of the aorta, on the right side of the ligamentum arteriosum. The superficial part of the cardiac plexus gives branches (*a*) to the deep part of the plexus; (*b*) to the anterior coronary plexus; and (*c*) to the left anterior pulmonary plexus.

The **deep part of the cardiac plexus** is situated in front of the bifurcation of the trachea, above the point of division of the pulmonary artery, and behind the aortic arch. It is formed by the cardiac nerves derived from the cervical ganglia of the sympathetic, and the cardiac branches of the vagus and recurrent nerves. The only cardiac nerves which do not enter into the formation of the deep part

of the cardiac plexus are the superior cardiac nerve of the left sympathetic, and the lower of the two superior cervical cardiac branches from the left vagus, which pass to the superficial part of the plexus.

The branches from the **right half** of the deep part of the cardiac plexus pass, some in front of, and others behind, the right pulmonary artery; the former, the more numerous, transmit a few filaments to the anterior pulmonary plexus, and are then continued onward to form part of the anterior coronary plexus; those behind the pulmonary artery distribute a few filaments to the right atrium, and are then continued onward to form part of the posterior coronary plexus.

The **left half** of the deep part of the plexus is connected with the superficial part of the cardiac plexus, and gives filaments to the left atrium, and to the anterior pulmonary plexus, and is then continued to form the greater part of the posterior coronary plexus.

The **Posterior Coronary Plexus** (*plexus coronarius posterior; left coronary plexus*) is larger than the anterior, and accompanies the left coronary artery; it is chiefly formed by filaments prolonged from the left half of the deep part of the cardiac plexus, and by a few from the right half. It gives branches to the left atrium and ventricle.

The **Anterior Coronary Plexus** (*plexus coronarius anterior; right coronary plexus*) is formed partly from the superficial and partly from the deep parts of the cardiac plexus. It accompanies the right coronary artery, and gives branches to the right atrium and ventricle.

The Celiac Plexus (Plexus Cœliacus; Solar Plexus) (Figs. 838, 848).

The **celiac plexus**, the largest of the three sympathetic plexuses, is situated at the level of the upper part of the first lumbar vertebra and is composed of two large ganglia, the **celiac ganglia,** and a dense net-work of nerve fibers uniting them together. It surrounds the celiac artery and the root of the superior mesenteric artery. It lies behind the stomach and the omental bursa, in front of the crura of the diaphragm and the commencement of the abdominal aorta, and between the suprarenal glands. The plexus and the ganglia receive the greater and lesser splanchnic nerves of both sides and some filaments from the right vagus, and give off numerous secondary plexuses along the neighboring arteries.

The **Celiac Ganglia** (*ganglia cœliaca; semilunar ganglia*) are two large irregularly-shaped masses having the appearance of lymph glands and placed one on either side of the middle line in front of the crura of the diaphragm close to the suprarenal glands, that on the right side being placed behind the inferior vena cava. The upper part of each ganglion is joined by the greater splanchnic nerve, while the lower part, which is segmented off and named the **aorticorenal ganglion,** receives the lesser splanchnic nerve and gives off the greater part of the renal plexus.

The secondary plexuses springing from or connected with the celiac plexus are the

Phrenic.	Renal.
Hepatic.	Spermatic.
Lienal.	Superior mesenteric.
Superior gastric.	Abdominal aortic.
Suprarenal.	Inferior mesenteric.

The **phrenic plexus** (*plexus phrenicus*) accompanies the inferior phrenic artery to the diaphragm, some filaments passing to the suprarenal gland. It *arises* from the upper part of the celiac ganglion, and is larger on the right than on the left side. It receives one or two branches from the phrenic nerve. At the point of junction of the right phrenic plexus with the phrenic nerve is a small ganglion

(**ganglion phrenicum**). This plexus distributes branches to the inferior vena cava, and to the suprarenal and hepatic plexuses.

The **hepatic plexus** (*plexus hepaticus*), the largest offset from the celiac plexus, receives filaments from the left vagus and right phrenic nerves. It accompanies the hepatic artery, ramifying upon its branches, and upon those of the portal vein in the substance of the liver. Branches from this plexus accompany all the divisions of the hepatic artery. A considerable plexus accompanies the gastroduodenal artery and is continued as the **inferior gastric plexus** on the right gastroepiploic artery along the greater curvature of the stomach, where it unites with offshoots from the lienal plexus.

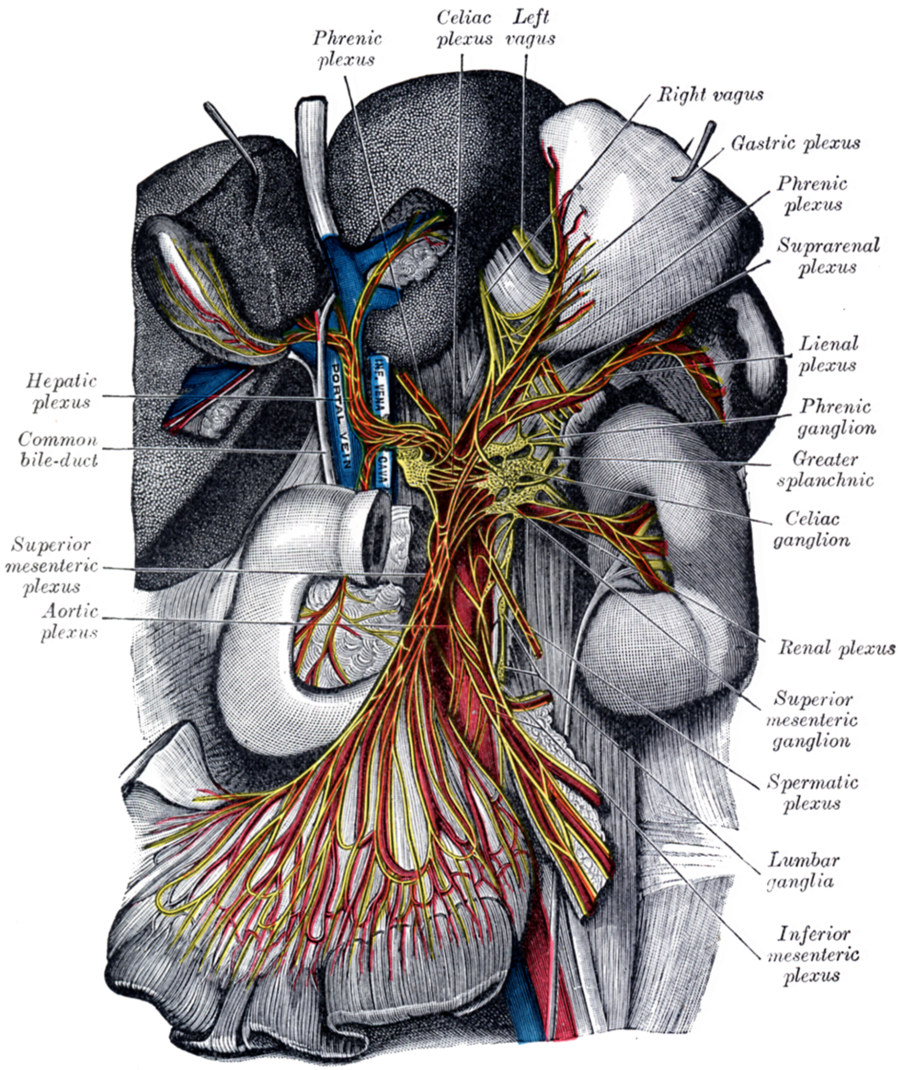


FIG. 848.—The celiac ganglia with the sympathetic plexuses of the abdominal viscera radiating from the ganglia. (Toldt.)

The **lienal plexus** (*plexus lienalis; splenic plexus*) is formed by branches from the celiac plexus, the left celiac ganglion, and from the right vagus nerve. It accompanies the lienal artery to the spleen, giving off, in its course, subsidiary plexuses along the various branches of the artery.

The **superior gastric plexus** (*plexus gastricus superior; gastric or coronary plexus*) accompanies the left gastric artery along the lesser curvature of the stomach, and joins with branches from the left vagus.

The **suprarenal plexus** (*plexus suprarenalis*) is formed by branches from the celiac plexus, from the celiac ganglion, and from the phrenic and greater splanchnic nerves, a ganglion being formed at the point of junction with the latter nerve. The plexus supplies the suprarenal gland, being distributed chiefly to its medullary portion; its branches are remarkable for their large size in comparison with that of the organ they supply.

The **renal plexus** (*plexus renalis*) is formed by filaments from the celiac plexus, the aorticorenal ganglion, and the aortic plexus. It is joined also by the smallest splanchnic nerve. The nerves from these sources, fifteen or twenty in number, have a few ganglia developed upon them. They accompany the branches of the renal artery into the kidney; some filaments are distributed to the spermatic plexus and, on the right side, to the inferior vena cava.

The **spermatic plexus** (*plexus spermaticus*) is derived from the renal plexus, receiving branches from the aortic plexus. It accompanies the internal spermatic artery to the testis. In the female, the **ovarian plexus** (*plexus arteriæ ovaricæ*) *arises* from the renal plexus, and is distributed to the ovary, and fundus of the uterus.

The **superior mesenteric plexus** (*plexus mesentericus superior*) is a continuation of the lower part of the celiac plexus, receiving a branch from the junction of the right vagus nerve with the plexus. It surrounds the superior mesenteric artery, accompanies it into the mesentery, and divides into a number of secondary plexuses, which are distributed to all the parts supplied by the artery, viz., pancreatic branches to the pancreas; intestinal branches to the small intestine; and ileocolic, right colic, and middle colic branches, which supply the corresponding parts of the great intestine. The nerves composing this plexus are white in color and firm in texture; in the upper part of the plexus close to the origin of the superior mesenteric artery is a ganglion (**ganglion mesentericum superius**).

The **abdominal aortic plexus** (*plexus aorticus abdominalis; aortic plexus*) is formed by branches derived, on either side, from the celiac plexus and ganglia, and receives filaments from some of the lumbar ganglia. It is situated upon the sides and front of the aorta, between the origins of the superior and inferior mesenteric arteries. From this plexus arise part of the spermatic, the inferior mesenteric, and the hypogastric plexuses; it also distributes filaments to the inferior vena cava.

The **inferior mesenteric plexus** (*plexus mesentericus inferior*) is derived chiefly from the aortic plexus. It surrounds the inferior mesenteric artery, and divides into a number of secondary plexuses, which are distributed to all the parts supplied by the artery, viz., the **left colic** and **sigmoid plexuses**, which supply the descending and sigmoid parts of the colon; and the **superior hemorrhoidal plexus**, which supplies the rectum and joins in the pelvis with branches from the pelvic plexuses.

The Hypogastric Plexus (Plexus Hypogastricus) (Fig. 838).

The **hypogastric plexus** is situated in front of the last lumbar vertebra and the promontory of the sacrum, between the two common iliac arteries, and is formed by the union of numerous filaments, which descend on either side from the aortic plexus, and from the lumbar ganglia; it divides, below, into two lateral portions which are named the **pelvic plexuses.**

The Pelvic Plexuses (Fig. 838).—The pelvic plexuses supply the viscera of the pelvic cavity, and are situated at the sides of the rectum in the male, and at the sides of the rectum and vagina in the female. They are formed on either side by a continuation of the hypogastric plexus, by the sacral sympathetic efferent fibers

from the second, third, and fourth sacral nerves, and by a few filaments from the first two sacral ganglia. At the points of junction of these nerves small ganglia are found. From these plexuses numerous branches are distributed to the viscera of the pelvis. They accompany the branches of the hypogastric artery.

The **Middle Hemorrhoidal Plexus** (*plexus hæmorrhoidalis medius*) *arises* from the upper part of the pelvic plexus. It supplies the rectum, and joins with branches of the superior hemorrhoidal plexus.

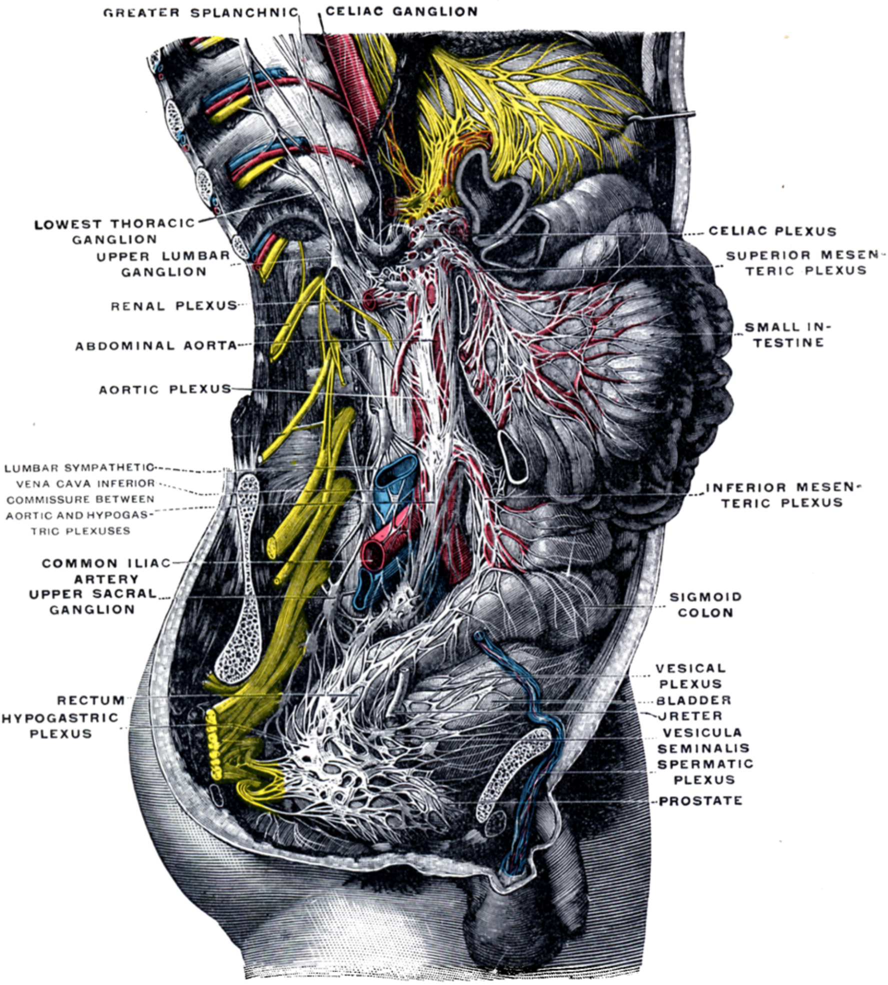


FIG. 849.—Lower half of right sympathetic cord. (Testut after Hirschfeld.)

The **Vesical Plexus** (*plexus vesicalis*) *arises* from the forepart of the pelvic plexus. The nerves composing it are numerous, and contain a large proportion of spinal nerve fibers. They accompany the vesical arteries, and are distributed to the sides and fundus of the bladder. Numerous filaments also pass to the vesiculæ seminales and ductus deferentes; those accompanying the ductus deferens join, on the spermatic cord, with branches from the spermatic plexus.

The **Prostatic Plexus** (*plexus prostaticus*) is continued from the lower part of the pelvic plexus. The nerves composing it are of large size. They are distributed to the prostate vesiculæ seminales and the corpora cavernosa of the penis and urethra. The nerves supplying the corpora cavernosa consist of two sets, the

lesser and greater cavernous nerves, which arise from the forepart of the prostatic plexus, and, after joining with branches from the pudendal nerve, pass forward beneath the pubic arch.

The **lesser cavernous nerves** (*nn. cavernosi penis minores; small cavernous nerves*) perforate the fibrous covering of the penis, near its root.

The **greater cavernous nerve** (*n. cavernosus penis major; large cavernous plexus*) passes forward along the dorsum of the penis, joins with the dorsal nerve of the penis, and is distributed to the corpora cavernosa.

The **Vaginal Plexus** *arises* from the lower part of the pelvic plexus. It is distributed to the walls of the vagina, to the erectile tissue of the vestibule, and to the clitoris. The nerves composing this plexus contain, like the vesical, a large proportion of spinal nerve fibers.

The **Uterine Plexus** accompanies the uterine artery to the side of the uterus, between the layers of the broad ligament; it communicates with the ovarian plexus.

BIBLIOGRAPHY.

Barker, L. F.: The Nervous System and its Constituent Neurons, 1901.

Herrick, C. J.: An Introduction to Neurology, 1915.

Huber, G. C.: Lectures on the Sympathetic Nervous System, Jour. Comp. Neur., 1897, vii, 73–145.

Ramón y Cajal, S.: Histologie du Système Nerveux, Paris, 1909.

Sherrington, C. S.: The Integrative Action of the Nervous System, 1906.

Streeter, G. L.: The Development of the Nervous System, Keibel and Mall, Manual of Human Embryology, 1912.